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Smithsonian•February/March 1993

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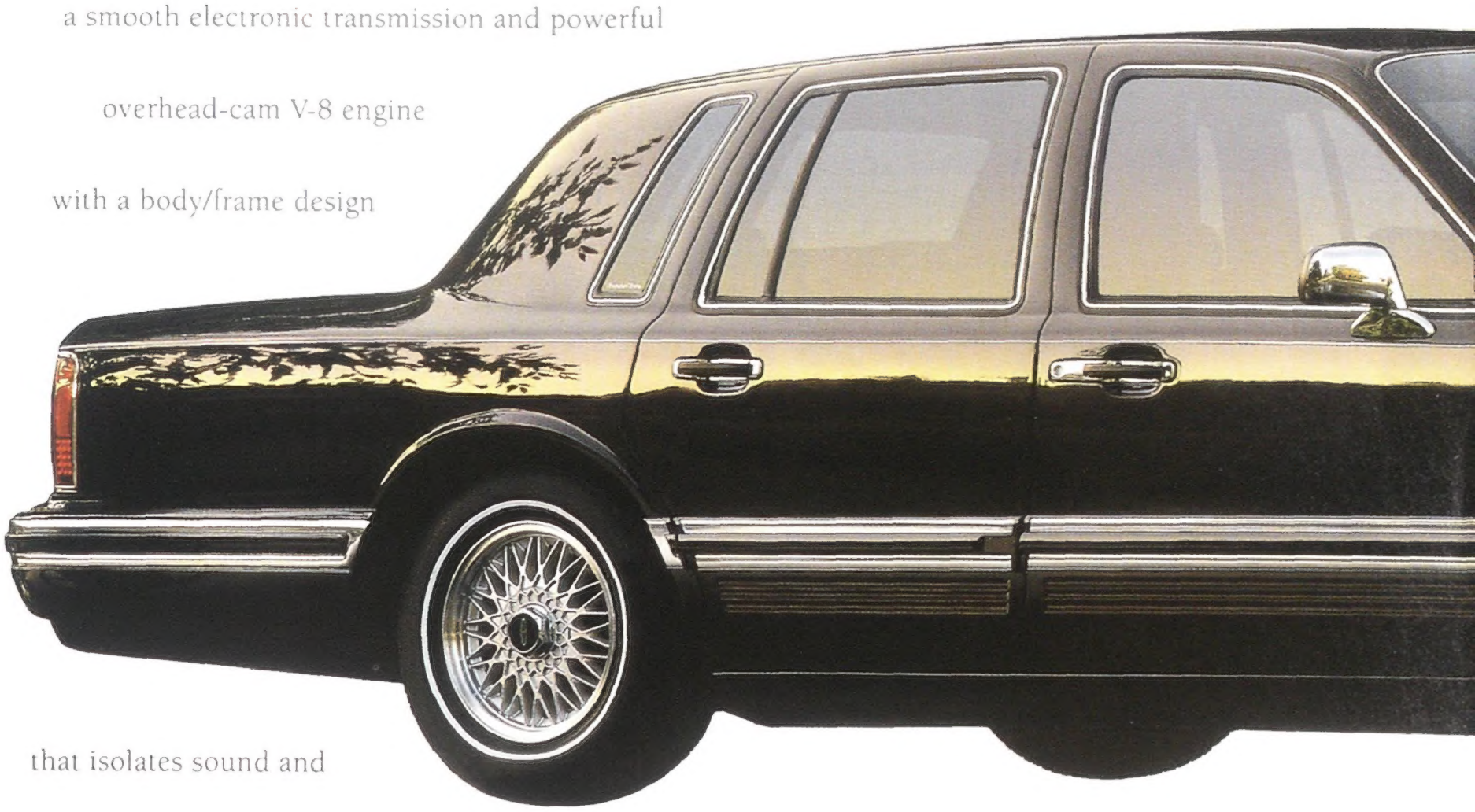

that isolates sound and reduces vibration. The result: Town Car not only *is* a dream machine...it also *drives* like one. ■ To this, Lincoln engineers added standard driver and right-front passenger air bags,** standard four-wheel disc anti-lock brakes and optional traction assist. ■ For more information, visit a Lincoln dealer or call 1 800 446-8888. Driving a Lincoln Town Car may seem like a dream. But owning one can be a reality.

*Based on a February 1991 USA TODAY reader poll. **Supplemental Restraint System. Always wear your safety belt.

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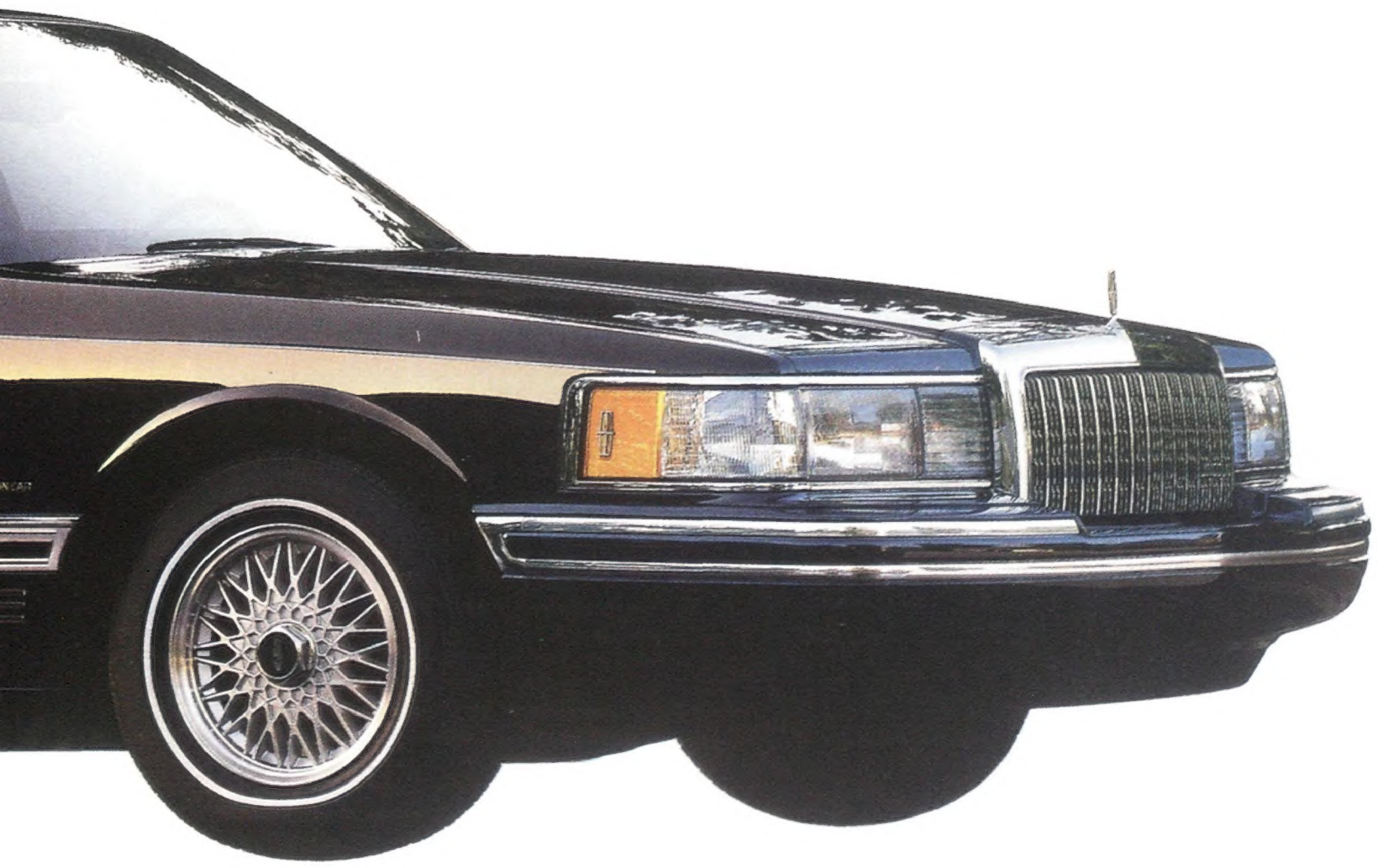

L I N C O L N T O W N C A R

WHAT A LUXURY CAR SHOULD BE

February/March 1993
Volume 7, Number 6

AIR&SPACE
Smithsonian

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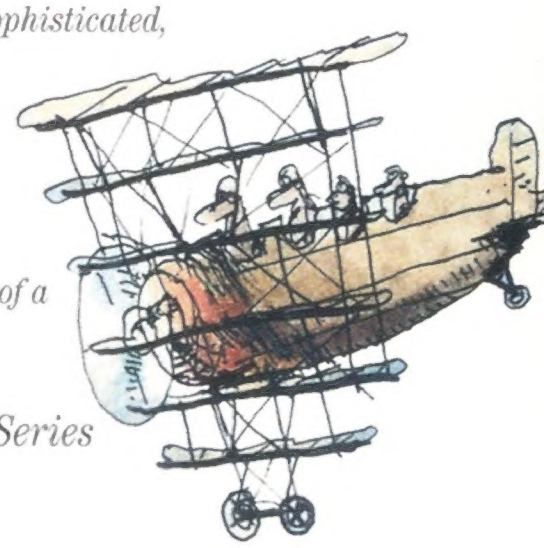

Cover:
Long still—but still imposing—the Spruce Goose's eight 3,000-horsepower engines dominate this photograph by Chad Slattery.

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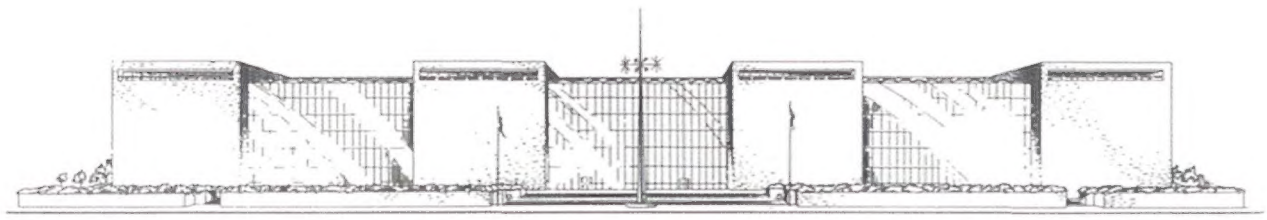

SUSTAINING TECHNOLOGIES

Science education is a national preoccupation this year. We look back at a time when American technology was unsurpassed and we could do anything if we set our minds to it.

We can't say that today, but we figure if science and technology made for a better world in the past, then more of the same should do it in the future, and we need only train more scientists to regain our strength.

The reality is that we already have an enormous number of scientists and engineers. So many, in fact, that young people coming out of the leading universities and technical schools can't find jobs for which they were trained. Industry can't use them, the universities are cutting back, and government laboratories are reeling from budget cuts.

Science, for many of us, is an end in itself: it increases knowledge. But to earn society's enthusiastic support, science must demonstrate its utility.

Science and engineering lead to novel industries through an intricate interplay that is still not properly understood, perhaps because each instance has a peculiar pattern never again precisely reproduced.

Some new industries are sustaining. Others become dead ends; they serve a short-term purpose but then lead no further.

A sustaining industry not only meets a genuine current need, it also leads to a successor industry and thus takes its place in a family tree. For example, the invention of aircraft produced an air transportation industry, which led to the creation of airports, the expansion of hotel and rental car enterprises, the start of an avionics industry, and the global positioning system, which is about to begin a revolution in all of navigation and in transportation safety. Each generation in this family tree is useful in its own right, often for quite diverse reasons, and each is partly responsible for the next.

Not all industries serve the dual purposes required. Some provide a valued service but produce no successors.

The medical industry for a long time was a sustaining industry. It not only saved lives but maintained the vigor of those whose health was restored. With increasing capabilities, medicine has further prolonged lives, to be sure, but without prolonging vigor and productivity. Unless the medical industry can again become sustaining, perhaps by endowing the aged with renewed vitality, it will exact a price society may be unwilling to pay. This issue was repeatedly brought up in the recent presidential elections.

So how does all this bear on science and technology education? It illustrates that technical expertise by itself is only a tool. That tool must be useful to society and must lead to sustaining industries. The scientific enterprise will thrive only as long as the education community clearly understands this.

For science to be useful, science education must be altered. In addition to providing the requisite training to produce specialists who will someday use a microscope, a telescope, or a particle accelerator, it should educate the public—farmers, mechanics, lawyers, business people, and politicians, who don't need detailed technical knowledge—how science and technology have to be used to benefit society.

Our present system of science and technology education is still concentrating on producing scientists and engineers, because we have not sufficiently appreciated all we might learn from the historians of science and technology, the political scientists, and the policy analysts, who try to unscramble the complex interaction of science, technology, and their service to society. We need to better understand those relationships if science and technology are to increase knowledge and serve society's needs.

That's where we really should be concentrating science education right now. But to date the idea still hasn't caught on.

—Martin Harwit is the director of the National Air and Space Museum.

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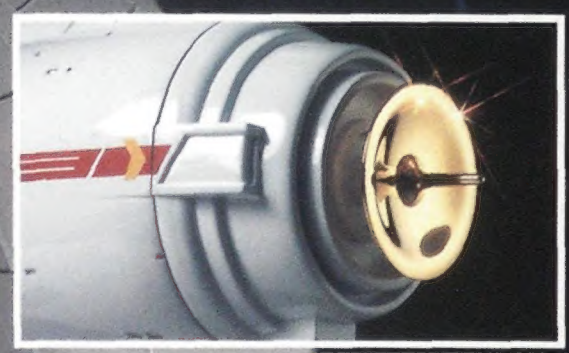

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LETTERS

Memories of Paul Garber

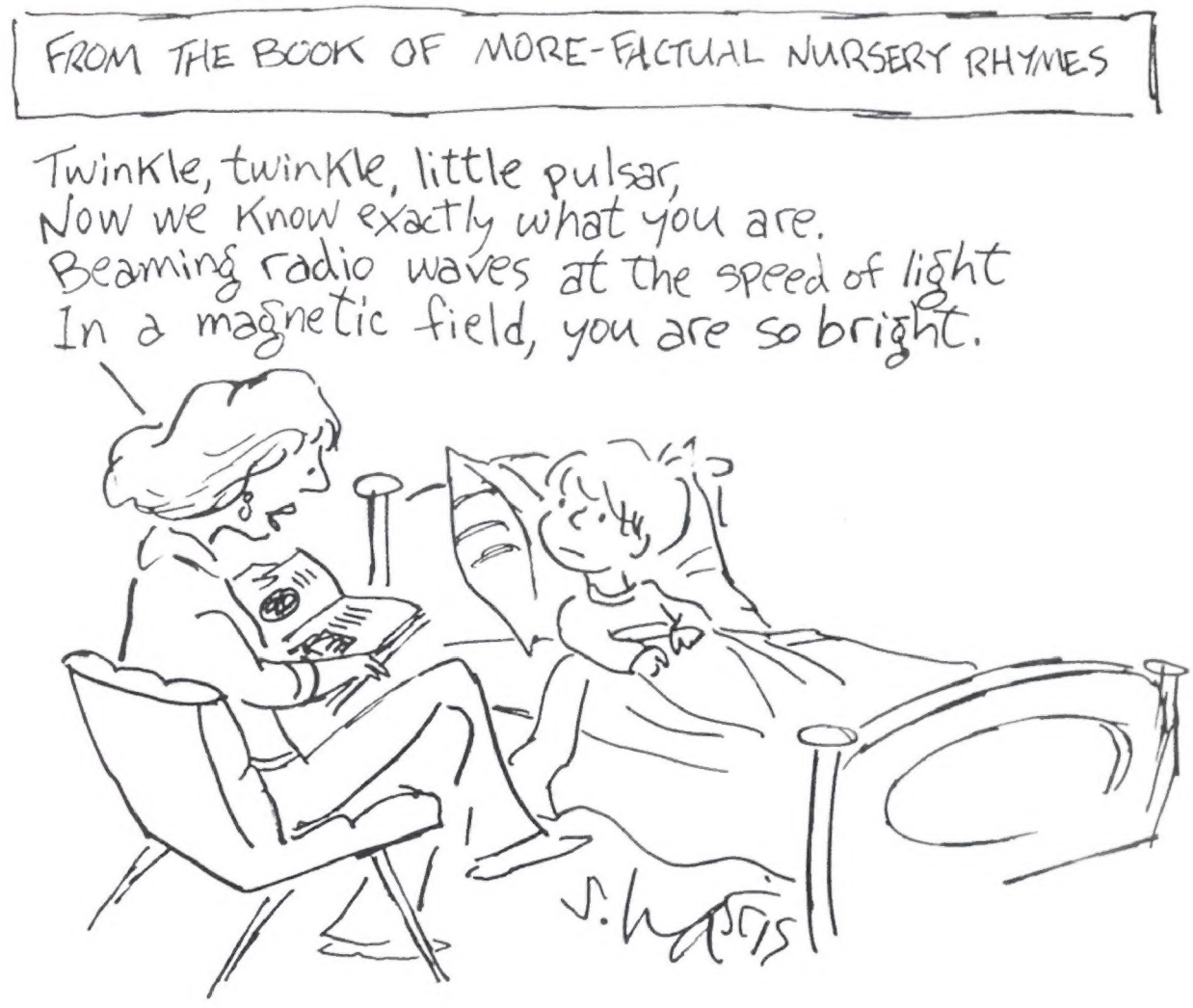
In July of 1976, I participated in a three-day Smithsonian Associates program that included private tours of the brand-new National Air and Space Museum and presentations by museum staff. The first evening our dinner speaker was Paul Garber. I vividly recall how he enthralled us with his recollections of encounters with famous figures from the annals of flight, and how we wished his talk could go on all night. It was clear to me that Paul Garber was a national treasure. I just hope that someone had the foresight to record Mr. Garber's oral history of flight so that later generations can experience his unique perspective on aviation.

Ronald F. Shea
Hamden, Connecticut

I first visited the museum's Paul E. Garber Preservation, Restoration and Storage Facility in Suitland, Maryland, in October 1981. The small group I was with was preparing to tour the facility under the guidance of a Navy commander, one of the facility's dedicated volunteer guides. Just as our tour was about to start, we were joined by none other than Paul Garber. He immediately put the guide at ease by stating that he himself would not take over as tour guide but would only offer background comments on the various displays. Nonetheless, the commander did the wise thing: he invited Mr. Garber to take the lead. Needless to say, all who were present will remember how fortunate they were to see the displays from Mr. Garber's perspective.

Robert N. Bachelder
Myrtle Creek, Oregon

In reading the issue dedicated to Paul E. Garber, the mention of his continued interest in kites triggered fond memories



of my acquaintance with this fine gentleman during World War II. One of the challenges in the early war years was to teach fliers and gunners to "lead" the target. At that time, I was chief designer at the Comet Model Company in Chicago. We became associated with Mr. Garber when he conceived of a controllable kite that could be maneuvered to provide a moving target for gunner training. Working closely with him, we developed the U.S. Navy target kite—basically a large Eddy kite, five feet high, that had near the bottom a fin and a rudder, which was controlled by flying the kite on two lines. On the face of the light blue fabric cover, a top view of a Zero or an FW-190 was stenciled in black. This evasive target could be deployed on a gunnery range, flown from a ship, or towed behind a jeep. Mr. Garber periodically made the trip to Chicago to review working models and suggest changes. When the design was firmed up, we built a number of prototypes and finally made an early production run.

Robert Reder
Glenview, Illinois

Mush!

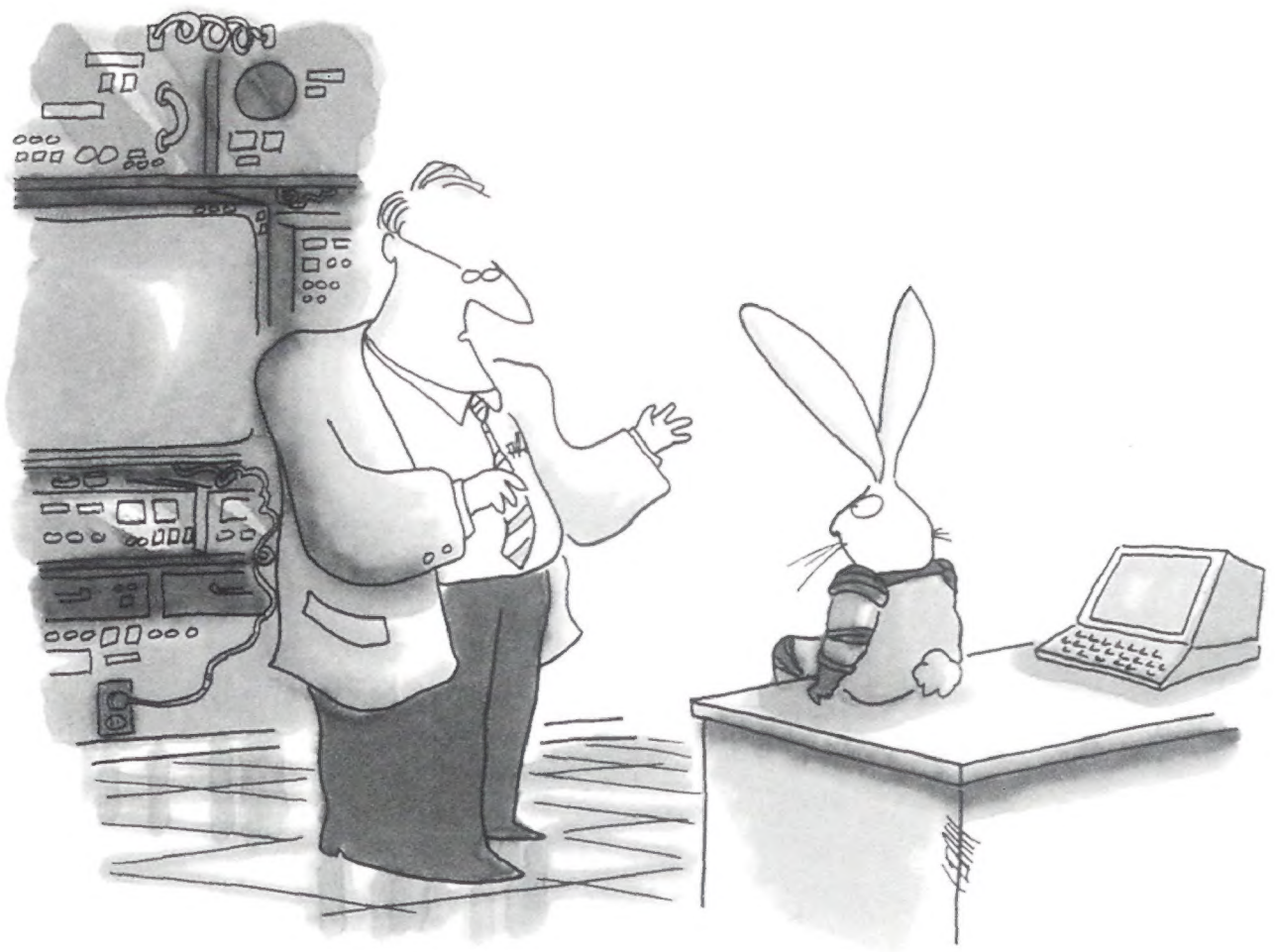
I enjoyed "Iced Lightning" by Karen Jensen (December 1992/January 1993). One person not mentioned in the text is the white-bearded gentleman in the red jumpsuit shown on page 34. No, that's not Santa Claus. It's Norman Vaughan, who led the sled dog team to rescue the downed fliers half a century before the expedition that recovered the P-38. He also flew with Richard Byrd in Antarctica. Now in his late 80s, Colonel Vaughan continues to run Alaska's 1,000-mile Iditarod sled dog race from Anchorage to Nome every year, calling himself the "oldest and slowest musher on the trail."

Mike Dunham
Anchorage, Alaska

Karen Jensen replies: It was another Admiral Byrd acquaintance, Freddie Crockett, who led the dog team to rescue the downed fliers. But Vaughan may have been the last to see the airplanes before they were buried in ice: after the rescue, the Army sent him by dogsled to retrieve a top-secret Norden bombsight that had been left in one of the B-17s.

The Mighty Eighth: More Memories

I spent 25 months as a radio mechanic in the 351st Bomb Group, which was stationed at Polebrook ("The Return of the Mighty Eighth," December 1992/January 1993). The group shared the base with the Royal Air Force for a



"That's true, the human crew will survive the star journey in suspended animation. But since you're the star of a cheaply produced Saturday morning cartoon, we thought you'd get by in limited animation."

short time, and the brass decided to have a parade to celebrate the transfer. Some of us were watching a unit of the RAF practice their formation on the tarmac. A motorcycle drove up behind us and soon a voice said, "Boy, they sure stomp the shit out of themselves, don't they!" We turned around. It was Lieutenant Clark Gable, on his Harley-Davidson. Despite his age, he flew combat missions and caught much combat footage as a photographer.

Morris Stern
Plainview, New York

The Eighth Air Force included some of us who were not flyboys but were attached to bomber or fighter groups in Britain. I was with the 900th Signal Company, which did fourth-echelon maintenance and installation on electronic gear—including radar—on those aircraft. We all wore Eighth Air Force shoulder patches. I still have mine.

Radar was still quite secret in those days. We had classes on British equipment taught by an RAF sergeant. He made us lock our lesson books in a safe every day. One day he told us we did not have to secure our books anymore. It was right after the Dieppe raid, when the British Rangers captured a complete German radar, including the tower and even the crew. At that point, the British realized that the Nazis knew as much about radar as we did.

Louis H. Eisen
Oceanside, California

My late grandfather served in the Third Army repairing rifles and other artillery. He told me many a story about his friendships with pilots, and if he were here today, he could relate to Frank Patton's ordeal. Many of the pilots and ground troops that my grandfather knew never returned. Not knowing what became of them, he would often sit down and cry.

Mark Whiteaker
West Seneca, New York

We Were There First

"Wide-Body" by Clive Irving (December 1992/January 1993) brought back memories of my brief encounter with the first production 747 at the new Everett, Washington plant. At the time, I worked for a company called Pay 'N Pak, a retail chain selling do-it-yourself building materials and related home hardware items.

In early 1967, Boeing invited us to bid on supplying containers for the new 747 program. Pay 'N Pak's president, being something of a maverick, saw this as an opportunity to visit the Everett plant, so we responded positively. Sure enough, Boeing eventually asked us to come up for a tour.

In one huge bay, the wood mockup of the 747 sat before us. We went up several stories to the cabin level for a look. The wide-body was truly awesome. Of course we were also shown the location of the cargo bay as well as details of the container requirements. Before we departed, our guide asked if we would like

UNIDENTIFIED FLYING OBJECT

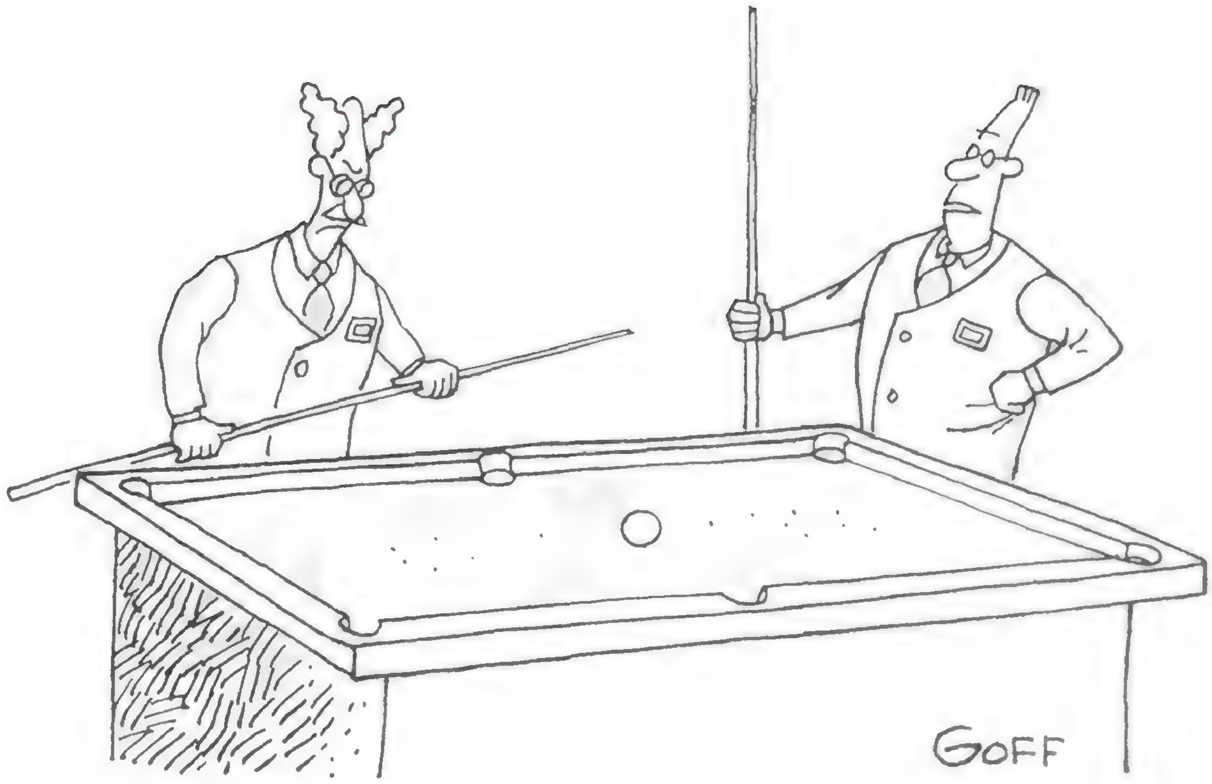
Can you identify the aircraft in this photograph? From time to time the National Air and Space Museum's archives division receives photos of vehicles that its staff cannot identify. They would appreciate any help in identifying this unusual twin-tail monoplane, which has a tricycle undercarriage. The original photograph was from the William J. Hammer Scientific Collection, but nothing else is known. If you can solve the mystery, send your response to: Air & Space/Smithsonian, *Department ASP, 370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.*

The photos that ran in the October/November 1992 and December 1992/January 1993 issues remain unidentified so far.

to see the actual number one production airplane, scheduled to go to Pan Am. This was in an even larger bay—a string of railroad boxcars at the far end looked like a toy train. As we approached the craft, our guide exclaimed that the two main sections of the fuselage had just been joined only minutes before. He asked if we would like to be the first non-Boeing people to step inside the first production 747 fuselage, and of course we did, stepping around workers still busy with assembly details.

Recently, I saw a picture of this number one Pan Am 747 being prepared for retirement at a desert location—and that's the rest of the story.

Robert F. Abell
La Jolla, California



"I win again, Dr. Fescue. And it's not *all the fault of curved space."*

Let's Work Together

Your essay describing the plight of our general aviation industry ("Ninety Years On," December 1992/January 1993) caused me sad reflections. In 1987 Calin Rosetti and I managed a flight around the world via the poles in a single-engine aircraft, despite experiencing a major structural failure of a wing on our Piper Malibu as we neared the North Pole in mid-winter. The incident could have killed us, but we survived and later completed our expedition.

We had declared that one of our trip's objectives was to promote general aviation. We went to senior engineers and officers of Piper, hoping to work with them to uncover the cause of our incident and correct any design or manufacturing problems that might have contributed to our frightening experience. They were not interested, and in fact they blamed us for the wing failure.

We worked independently with airframe and metallurgy experts around the world, who examined the problem

and suggested design changes that could significantly enhance the safety of the Malibu. Piper didn't want to hear it, perhaps fearing that admitting deficiencies would subject them to further litigation. In the end, we joined the line of litigants in order to try to force positive change in the aircraft's design and construction. That ended quickly when Piper entered Chapter 11.

At least five Malibus fell out of the sky. Though we can't identify the cause or causes with certainty, we do know that the Malibu wing could easily have been made stronger and safer at little cost. Piper could have cooperated, and perhaps lives could have been saved.

Your essay is correct in pointing out that legal problems have contributed significantly to the near demise of our general aviation industry, but it is sad to think that manufacturers' fear of liability could in fact have contributed to some accidents. If the industry is to survive, it must work with the users rather than take an adversarial stance. Most importantly, our government must regenerate an environment where such cooperation is possible and where enterprise can flourish again.

Richard D. Norton
Wyndmoor, Pennsylvania

Thanks a Lot

I just read with great interest "Survival 101" by Fred Reed (October/November 1992). I myself spent three weeks this past summer at Fairchild Air Force Base going through what I would classify as a living hell. Obviously, I'm not an outdoors person. I'm a pilot, and getting as far away from the ground as possible is my goal in life. However, I am glad that I went through this hell under the watchful eyes of the survival instructors rather than trying to wing it on my own in an unfriendly territory.

One last thing: I'm sure that once survival school is over, most instructors never get personal feedback from their students. Well, I've got some: You all were difficult, irritating, demanding, obnoxious S.O.B.'s! Thank you!

Captain David M. Cohen
Loring Air Force Base, Maine

Corrections

The author of *Where Is Joe Merchant?* (Reviews & Previews, December 1992/January 1993) is Jimmy Buffett. After over 20 years in the music business, it's amazing how many times his name is incorrectly spelled.

Edward C. Dominguez
Farmington Hills, Michigan

An Update in the December 1992/January 1993 issue (Soundings, p. 16) stated: "The plant in which Ford built thousands of B-24 bombers during the war will shut down in 1993." The General Motors facility at Willow Run scheduled to close is the Buick-Oldsmobile-Cadillac Group Willow Run Assembly plant, which during World War II was used as a warehouse for storing B-24 parts. The old Ford bomber plant, on the other hand, currently houses GM's Hydra-Matic Division, which makes the transmissions for most General Motors-built vehicles, as well as for several other manufacturers' vehicles. This building will continue to operate into the foreseeable future.

Todd Hackbarth
Belleville, Michigan

We welcome comments from readers. Letters must be signed and include a daytime telephone number. Letters may be edited. Write to Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024. Air & Space is not responsible for the return of unsolicited photographs or other materials.*

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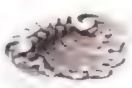

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CHAD SLATTERY

For years Colonel Tom Hornung, head of the Air Force's western region public affairs office, had been teasing the owner of Robin Rose Ice Cream and Chocolates in Venice, California, with bizarre suggestions for new flavors. "Most of his flavors ranged from whimsical to outright funny to just plain inedible, like linguini and clam, sushi, and pigs in a blanket," says Rose, whose reputation for marketing unique flavors like chocolate raspberry truffle won her the National Ice Cream Retailer of the Year title. But when Hornung came up with prune, Rose not only took him up on it but named the result after its founder's employer. When Creamy Air Force Prune debuted last August at Hornung's retirement party, it was a sweet success.

Air Force Prune is an unexpectedly tasty blend of walnuts, rum, and, of course, prunes. Rose admits it takes courage to order a scoop. "Air Force officers are embarrassed at the prospect of eating prunes in public," she says, adding that it requires overcoming the prune-induced giggle factor, a reaction unique to Americans. "In Europe, where there's no squeamishness associated with prunes, they're widely used in desserts," Rose says. "Prunes are not something that you eat just when you need them. You eat them in this ice cream because they taste good."

Rose is quick to add that Air Force Prune has not been sanctioned by the Air Force itself. "We take pains to let people know that this doesn't say *United States* Air Force," she says. And if any Navy officers have a flavor to top prune, Rose says she's all ears.

—Chad Slattery

TERRY GWENNAWG KREIL

Qantas' Bush-League Beginnings

Seventy years ago, Jack Hazlett, denied a pilot's license because of a bad heart, became a mechanic on the first Qantas airliner. Last November, at a reenactment of the airline's first flight, the 95-year-old veteran of Gallipoli celebrated with two loops and a roll over the Australian Outback in a de Havilland Tiger Moth.

"I think I've grown out of my heart condition now," Hazlett said as he climbed out of the 1942 biplane. Flying in the passenger cockpit, he headed up a flight of 40 light aircraft that retraced the 600-mile Outback route. Inaugurated on November 2, 1922, the route linked a half-dozen railhead wheat and cattle settlements in the desolate Queensland bush. The reenactment flight, called "Qantas Rising," raised funds for a Qantas museum being built at Longreach in Queensland, the airline's first base. It will document the Outback years, when Qantas changed forever the lives of isolated Australians.

As a mechanic on Qantas' Armstrong Whitworth FK-8 airliners, Hazlett serviced the converted World War I bombers and pulled their propellers through by hand to start their engines. He also acted as cabin attendant, serving the two passengers

CHRIS CONKRIGHT

Residents of Myrtle Beach, South Carolina, must have thought that Chicken Little was right when this crowd of 200 broke the old record of a 150-skydiver formation. Last October six airplanes carried the jumpers to 18,000 feet over the beach town for numerous assaults on the record. On the 24th jump, they linked up successfully.

sandwiches and tea from a thermos.

At McKinlay's Walkabout Hotel (site of the pub brawl in *Crocodile Dundee*), Hazlett chatted with the settlement's 28 residents and a brace of Qantas pilots manning a Piper Aztec in the near-100-degree heat. "That's why we always took off at first light and landed before this terrible mid-day heat," Hazlett said. "Those old Armstrong Whitworths were built for cool European conditions and couldn't get airborne in these temperatures. Their engines were beat up and had tiny radiators. We called 'em 'boiling Beardmores.'"

Relatives of the airline's founder, the first male and female passengers, and several pioneering Qantas pilots were among the crews taking part in the reenactment. To get a feel for the old days they flew part of the route in open-cockpit biplanes. After a chilly dawn flight to the cattle settlement of Tambo (population 189), they thawed out at a steak and egg campfire breakfast on the edge of Tambo's scrub and dirt airstrip.

Peg Ballinger, 70, talked about the last time she flew into Tambo. It was 1922, and she was just 10 weeks old, the first child Qantas had ever flown. "Mother wrapped me in a blanket and they placed me in a locker that was formerly used to hold the bombs," she said. "Nevertheless, it seems that I turned blue from the cold when we got up high. As we flew over my father's property, mother threw an orange wrapped in a nappy overboard to tell him we were all right." In Longreach, Ballinger's seven children—four of whom are pilots—and their families showed up to celebrate both their mother's and Qantas' 70th birthdays.

—Terry Gwynn-Jones

Everything Has a Price

Last November Odyssey Auctions hosted a unique sale in Beverly Hills. Among the collectibles offered were Amelia Earhart's goggles, a Soviet spacesuit, and items from "The Pete Conrad Collection," including a razor, flags, and a tie tack that accompanied him on Apollo 12, as well as a prototypical urine collection device.

Odyssey president Bill Miller obtained the Conrad collection after meeting the Gemini, Apollo, and Skylab astronaut in the company's gallery. "I found out Pete had a great deal of space memorabilia just lying around his house," he says. "He wasn't getting any enjoyment out of it, and I explained to him that there were a lot of people out there who would." A lot of wealthy people, apparently. The tie tack went for $750, the razor $300, the sunglasses $900, the Princeton University flag $2,250, and backstraps from his spacesuit commanded $4,000. "We've had such a great response we're going to do it again," says Miller.

Dan Slater, a Southern California design engineer, was the lucky bidder on the urine collector. "I paid $5 for my first one back in the '70s, and this one cost me $500," he says. "I guess that just shows how much the market has increased."

ODYSSEY AUCTIONS

The Kansas Cosmosphere snapped up Vladimir Lyakhov's spacesuit, worn on the Soyuz TM-6 mission in August 1988, for a mere $49,500. "Usually we don't like to buy them," says Cosmosphere executive director Max Ary, "but Russian artifacts are next to impossible to obtain."

While some bidders sent prices through the stratosphere, others were cautious. "Four hundred and fifty dollars for a signed Neil Armstrong photo?" exclaimed space aficionado James Dinwiddie. "That's nuts. The guy's still alive."

—D.C. Agle

UPDATE

COBE Proves Cosmic Theory

Data from the Cosmic Background Explorer ("Ancient Whisper," April/May 1992) has revealed that 99.97 percent of the radiant energy in the cosmos was emitted within a year of the universe's birth. This finding, announced last January, corroborates the Big Bang theory.

FRED D. JONES/NASA LANGLEY

The Shuttle's Cheap Seats

Today's astronauts have to make upwards of a thousand runway approaches in a jet trainer before qualifying to land a space shuttle. Now the average Joe can do it for $8.75 at Space Center Houston.

The Disney-like tourist attraction opened near the Johnson Space Center last October. Space Center Houston aims to be "the closest thing to space on Earth," and veteran astronauts say it's right on target with a video game that puts you in the commander's seat of a shuttle on final approach to Kennedy Space Center in Florida.

"It's harder than the real thing," says four-time shuttle flier Dan Brandenstein, who consulted with programmers of the six mini-cockpits just before leaving NASA last year. "We tried to get it as close as possible to what I remembered."

One of the $70 million pavilion's biggest draws, "Land the Shuttle" is fashioned after a simulator astronauts use to learn the finer points of flying the orbiters. Players see the same cartoonish views of KSC but don't feel the motion of the real trainer.

What "Land the Shuttle" lacks in special effects it makes up for with audio—tires screeching, metal crunching, and glass shattering when you crash. "A little guy comes up with his hair all messed up and says, 'Well, that was different!' " says David Walker, who commanded his fourth shuttle mission last November. "That means you really hamburgered it."

SPACE CENTER HOUSTON

"This is not a game," the little guy cautions as he hands you the controls at 10,000 feet. "This is 85 tons of spaceship plunging toward Earth. You'll be on the ground in two or three minutes. The big question is, will you land with the pointy end forward and the wheels down?"

I put the question to several hotshot pilots. "I told 'em it's too hard," says two-time shuttle pilot Mike Baker. "You've got to play it as a video game, not the shuttle," advises Tom Henricks, scheduled to pilot his second mission in February. "It'll fool you, and it'll fool you worse if you've ever flown a shuttle," says Walker.

"I think I got a pretty rave review from the little guy on the screen," Brandenstein says. "At least he didn't give me that line that if I did 17 more of those I'd have a golf course."

—Beth Dickey

UPDATE

GPS Covers Its Bases

The Global Positioning System ("You Are Here," June/July 1992) found a novel application last November when surveyors used the Navstar satellite system to pinpoint the location of home plate for Denver's new Coors Field, scheduled to open in 1995. The site of the plate is a reference point crucial to all dimensions of baseball stadium construction.

NASA's Latest Capsule

Here's a switch. NASA recently launched a vehicle *into* Earth instead of from it. Last December a time capsule was buried at

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the Langley Research Center in Hampton, Virginia, in the last of a series of ceremonies that commemorated the 75th anniversary of another foray into the Virginia soil: the groundbreaking that marked the birth of the center in 1917.

Employees were invited to submit suggestions for the capsule's contents, and more than 50 items were packed inside. The capsule will be opened in 25 years, on the facility's 100th birthday, and after employees peruse the collection, they will reseal it for another half-century. An aluminum sculpture designed by John Mouring, Langley's chief architect, forms an arch straddling the capsule marker. Broad at the base, it tapers sharply to form a needle pointing to the heavens—or, as one observer remarked, the world's largest tuning fork.

Artifacts of Langley's space achievements include a packet of tomato seeds that orbited Earth for six years in the Long-Duration Exposure Facility, which was developed at the research center; a microdot like the one on the Viking Mars lander, containing a list of Viking participants; and a copy of a component from a work platform designed at Langley and used by *Endeavour* astronauts in the rescue of Intelsat VI last May.

On the aviation side, the capsule contains a "remove before flight" tag from Boeing's first 737, which has served as a test bed at Langley for most of its 25 years. Photos and other accounts document the *White Pelican*, the world's largest paper airplane, which flew in the Langley hangar last spring to qualify for inclusion in the Guinness Book of World Records.

Most of the time capsule items are associated with fairly recent history, but at least one dates back to the days of NASA's predecessor, the National Advisory Committee for Aeronautics. It's an early flight recorder, forerunner of today's black box. Developed at Langley, the device recorded acceleration and altitude on small plates of smoked glass.

There were also items that reflected life at Langley: cafeteria menus, union agreements, a phone directory, retirement notices, and a NASA badge and car decal. Group photos of children in the day care center were added, with the thought that some of them might be among the employees opening the capsule in 2017.

Just before the capsule was lowered into its concrete chamber, Lee Beach, the center's acting director, read a statement that will be the first item those lifting the lid will find. "We salute you, our posterity,

and hope we helped deliver a creative, productive, and sound Langley Research Center to you in 2017," it concluded. "We have carefully selected these symbols of our history. Take some, leave some if you wish, add your own, and pass this legacy of now 100 years on to our collective future."

—*Lester A. Reingold*

UPDATE

New Solar Systems?

The Hubble Space Telescope has detected 15 young stars in the Orion Nebula surrounded by bands of dust and gas that are accreting into planets ("The Planet Hunters," October/November 1992). Though the jury will be out for a few million years, University of Massachusetts astronomer Stephen Strom says this provides "dramatic proof" of the prevailing planetary formation theory, adding, "You've got all the ingredients there to make a solar system."

A Trial Trial

Given the public's hostility toward lawyers, it's difficult to imagine much interest in would-be attorneys arguing fine points of law. But last September, a moot court, or mock trial, conducted by four law students at George Washington University in Washington, D.C., before three judges of the International Court of Justice drew about a hundred lawyers, business people, and law professors from around the world.

The facts of the case, devised by a committee of U.S. members of the International Institute of Space Law, centered on the rescue and return of an inoperative communications satellite. There were related issues of liability for damages inflicted on the satellite during recovery, as well as conflicting claims over who actually owned it—cutting edge issues in the law of abandonment and salvage in space. Except for the recoveries of the Westar communications satellite and Indonesia's Palapa, there was very little if any real precedent for the students to draw upon. The laws covering salvage at sea, while pertinent, were not sufficient to address the central issues.

Manufacturers of launch vehicles, satellites, and components were involved, as were launch service providers and space insurance underwriters. There were groundbreaking aspects of the "make it up as you go along" arguments, and it was clear that the judges were intrigued. Judge Manfred Lachs, a pioneer in space law, praised both teams on the quality of their briefs and oral arguments.

The plaintiff was represented by Stanimir Alexandov and Tod H. Cohen; Stephen Hawk and Peter Borys represented the defendant. The sitting judges, in addition to Lachs, were Gilbert Guillaume and Stephen M. Schwebel.

The plaintiff argued that it still held title to the inoperative satellite even after receiving insurance proceeds, and, further, that the defendant was liable for damage to the satellite during a recovery operation. The defendant argued that payment of insurance at 100 percent of value transferred title to the insurer, which had arranged for recovery through the defendant. The defendant also cited maritime law relating to abandonment and wanted full reimbursement for the recovery operation. In the end, the plaintiff's arguments prevailed, but there were no losers in this moot court.

Hundreds of millions of dollars are at risk and new law is being established for

rapidly developing and diversifying commercial space activities. What was demonstrated at the moot court was a step in the passing of the torch from the founding generation of space lawyers to a generation that will focus much of its attention on developing commercial law for space exploration.

—*George Robinson*

UPDATE

The Shape of Wings to Come

Set the Wayback Machine, Sherman, for 1986 and the premier edition of *Air & Space/Smithsonian*, which featured "The Enduring Biplane."

Julian Wolkovitch's joined-wing high-speed biplane design has resurfaced in the Boeing EX, a potential replacement for the Navy's E-2C Airborne Early Warning aircraft, with the joined wing serving as a mounting platform for an antenna that will dispense with the E-2's rotodome.

A Goldin Opportunity

NASA officials didn't exactly go to the heartland of America when they hit the road last fall in search of public opinion about the U.S. space program.

Armed with charts and graphs depicting the space agency's $14 billion budget and the education levels of its 22,000-plus employees, top NASA officials visited six cities in public sessions intended to emulate town meetings, where people were invited to line up at open microphones and speak their minds. Officials said they also hoped to acquaint the public with a "new vision" emerging from six months of bureaucratic introspection and to reach businesses not yet involved with the space program.

The meetings were situated in metropolitan areas with at least an aerospace research facility, if not a major aeronautics or space employer, such as Seattle,Washington, with its Boeing plant; Hartford, Connecticut, headquarters of Pratt & Whitney; and Carson, California, near NASA's Jet Propulsion Laboratory. Attendance averaged about 700.

If there are voters who hate the space program, as some members of Congress claim, they didn't take the opportunity to tell NASA. "I haven't heard very much criticism," NASA administrator Daniel Goldin said in Tampa, Florida, where the fifth town meeting took place last December.

According to Goldin, folks talked about NASA's troubled space exploration initiative as if their lives depended on it. "In Los Angeles, a young man came up to me and said, 'Mr. Goldin, I'm 23 years old and I want to know right now: Are we going to Mars? Tell me now because I don't want to be old and gray and walk with a cane and know we didn't go to Mars.' "

Then there were those who came seeking the truth about UFO documents rumored to be hidden in government archives. "What is NASA's official position on UFOs and when will you release the information to the public?" one man in Tampa demanded.

Kids asked when NASA was going to send a child into space, when it would build a spaceship that could break the "light barrier," and why, if NASA had so many smart employees, did the shuttle blow up?

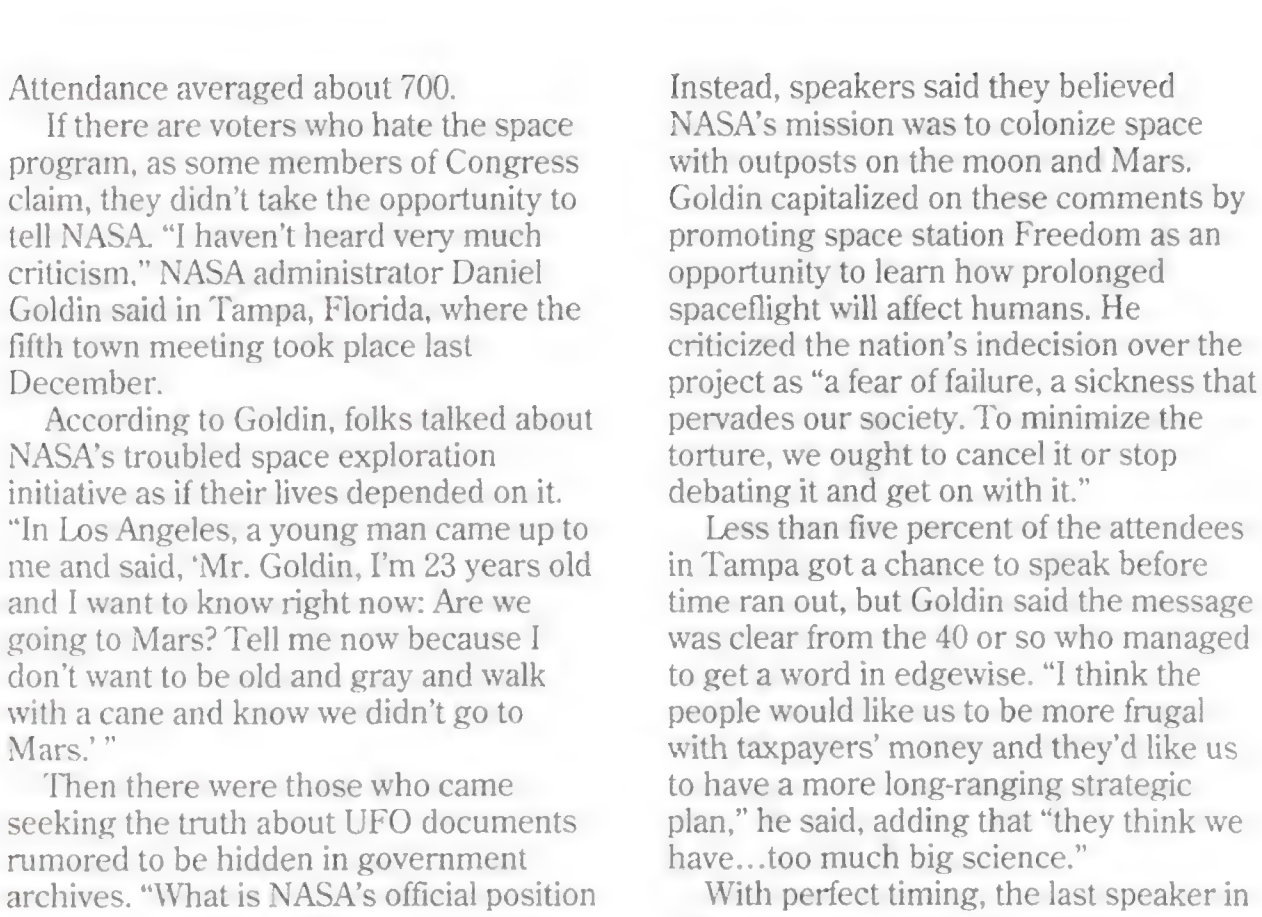
There was no outspoken support for the proposed $30 billion space station. Instead, speakers said they believed NASA's mission was to colonize space with outposts on the moon and Mars. Goldin capitalized on these comments by promoting space station Freedom as an opportunity to learn how prolonged spaceflight will affect humans. He criticized the nation's indecision over the project as "a fear of failure, a sickness that pervades our society. To minimize the torture, we ought to cancel it or stop debating it and get on with it."

Less than five percent of the attendees in Tampa got a chance to speak before time ran out, but Goldin said the message was clear from the 40 or so who managed to get a word in edgewise. "I think the people would like us to be more frugal with taxpayers' money and they'd like us to have a more long-ranging strategic plan," he said, adding that "they think we have...too much big science."

With perfect timing, the last speaker in Tampa asked, "How can a citizen, an American, and an advocate of the space program help?"

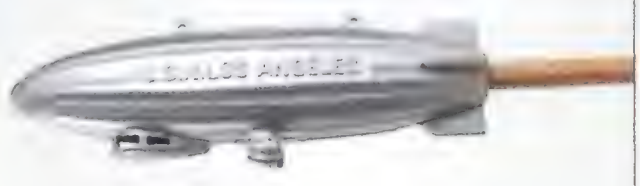
The question seemed destined to go unanswered until Robert Rhome of NASA's microgravity science and applications division replied meekly, "If you tell someone and they tell someone and they tell someone, that would be a very big help."

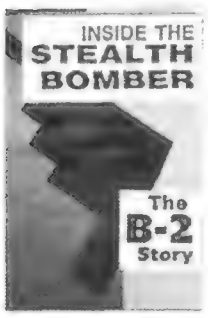
—*Beth Dickey*



CHARLES H. PHILLIPS (2)

Get the lead out with a collection of pencil sharpeners from the National Air and Space Museum gift shop. Purists beware: aircraft configuration has been severely modified to accommodate acuminating device.





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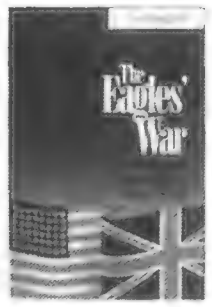

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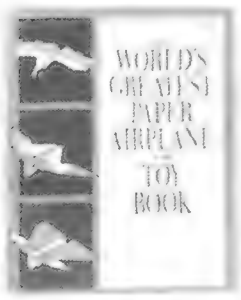

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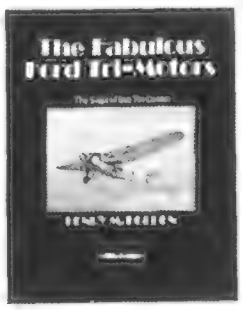

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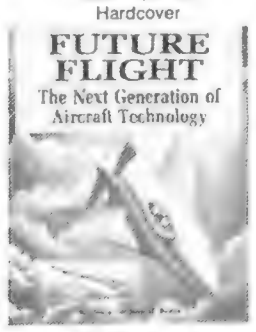

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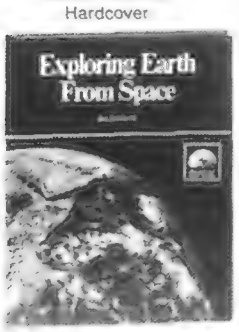

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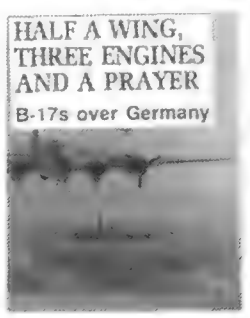

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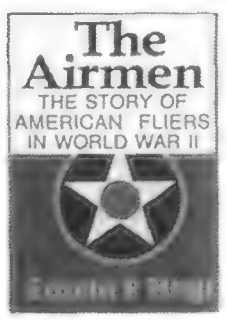

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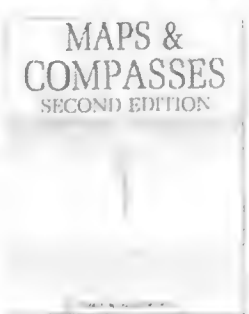

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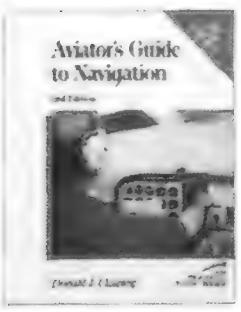

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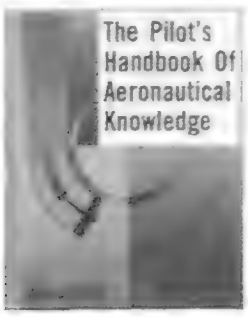

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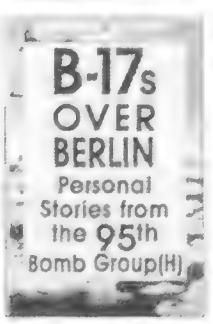

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AS293

Truth Before Beauty

David Hallam, a metals conservator with the Australian War Memorial in Canberra, wasn't exactly shocked by what he saw on his first visit to the Museum's Paul E. Garber Restoration, Preservation and Storage Facility. "I'd been forewarned," Hallam says of his 1984 internship. But he does admit to being surprised that in the Museum's handling of its priceless artifacts, "there wasn't more science involved."

Whereas art collectors had long since abandoned, say, brightening up a Michelangelo by adding a coat of new paint or updating a da Vinci by reworking its background, Hallam believed he saw the equivalent going on in the Museum's handling of its air- and spacecraft. Objects being prepared for display were routinely subjected to heavy restoration either to compensate for the deterioration caused by inadequate storage or to transform an undistinguished artifact into one more fitting for a particular exhibit. But Hallam feared that important information about the original craft was being lost. "I think that for the most part it helped to be an outsider," he says of his decision to volunteer his opinions. "I guess I just spoke my mind."

Hallam urged Museum staff members to think in terms of conserving rather than restoring, and they now credit him with setting in motion a gradual shift in the way the Museum cares for its artifacts. In one of the earliest signs of change, the Museum hired its own chief conservator, Ed McManus, during Hallam's second visit in 1989.

DALE HRABAK

Had the Museum acquired its P-51 Mustang more recently, it might have been a horse of a different color.

"Restoration can be harmful if not guided by ethical standards and principles," McManus says, citing a hypothetical museum display of George Washington's hatchet: it's the genuine article, "except that the head's been replaced twice and the handle's been replaced three times."

Safeguarding authenticity, however, means respecting an individual artifact's history, which sometimes interferes with creating the most pleasing or interesting display. In its early days, the Museum would occasionally cloak aircraft in paint schemes they never actually wore in service for the sake of rounding out an exhibit. The North American P-51D Mustang on display in the World War II gallery, for example, is painted in the colors of an Eighth Air Force squadron stationed in Raydon, Suffolk, England, even though that particular airplane never left the United States.

Now "we pay a lot more attention to the provenance of an individual artifact," says aeronautics department chairman Tom Crouch. For example, the Museum currently has a Lockheed C-130 Hercules with a Vietnam combat record in storage at Washington-Dulles International Airport, but it would consider "de-accessioning" the craft to a museum that wants a C-130 if it could get another with a record of combat in both Vietnam and Desert Storm so it could be exhibited in either context.

Likewise, the Museum is struggling to save a mid-1950s Vickers Viscount, a small, medium-range airliner currently at an airport in Georgetown, Delaware. "We're not doing that because we couldn't find a better Viscount," Crouch says. "It's because that one flew for Capitol Airlines, an airline that's unrepresented otherwise in the collection, and one of some importance. And so the individual history of an aircraft becomes more important."

There is still some debate in the Museum about just how far the principles of conservation should be applied. "The thing that you don't want to do is to treat the aircraft in the collection like model airplanes that you can paint any way that you want," says aeronautics curator Tom Dietz, one of the Museum's purists on this issue. "We're not talking about somebody's old Chevy here. We're talking about objects that have their own histories."

In the case of exhibiting the P-51, Dietz sees two possible compromises: showing it in its rollout markings, so that it remains true to one aspect of its actual history, or exhibiting it in markings it never actually had and saying so in an accompanying label. The Museum chose the latter route; Dietz would prefer the former.

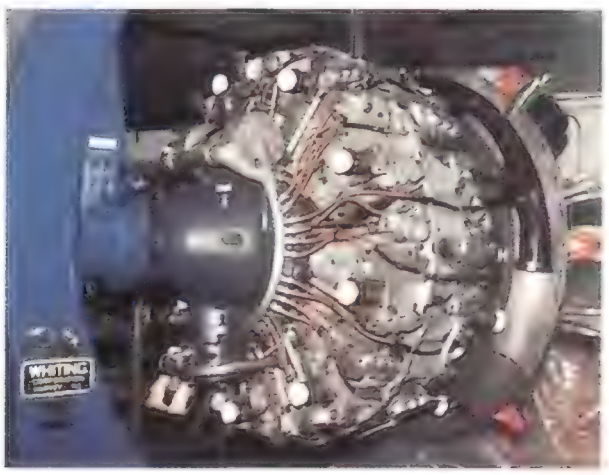
But Tom Crouch feels the P-51, which flew with the Texas Air National Guard, is an allowable exception to the rule. "I argue, in fact, that the reason you collect an airplane like a P-51 is because of its combat record," he says. "And therefore, as long as you don't misrepresent it, you

ought to be able to show it in [a paint scheme] that was typical for that airplane."

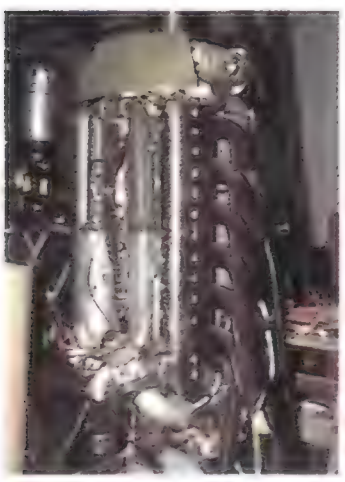
However, other aircraft in the Museum probably would be handled differently if acquired today, says Crouch. The Museum's Vought-Sikorsky OS2U Kingfisher (see In the Museum, October/November 1988), for example, had a distinctive service record yet has been painted with generic markings. And a 1914 Blériot XI monoplane had its wing fabric completely replaced in the late 1970s; today, the Museum probably would make a greater effort to keep its original skin intact and on display.

One offshoot of preserving as much original material as possible is "that you're going to see, oh, perhaps airplanes that look a little wearier on exhibit as time goes by than in the past, when everything that came out of [the Garber facility]

Two engines undergoing refurbishment at the Garber facility illustrate the changing philosophy toward restoration. One of the four Wright radials on the B-29 Enola Gay *was completely overhauled and cleaned down to its piston heads.*



MICHAEL RUZICKA (3)



A later project, a Japanese seaplane, is being cleaned lightly. Its in-line engine has not been disassembled. "It may not be beautiful," says Ed McManus, "but it's honest."

looked as though it just rolled out of the factory door," Crouch says. A good example is the Museum's recent refurbishment of a Republic P-47 Thunderbolt (see In the Museum, August/September 1992). "It looks much more like an operational aircraft because it's got scratches and dents and things," Dietz says.

What to preserve and what to restore will be decided on a case-by-case basis, Dietz says, and that's where conservator Ed McManus comes in. With the help of the Smithsonian Institution's conservation analytical laboratory, he'll determine what's possible to save and what's not. His approach agrees with David Hallam's rule for handling artifacts. "Everything you do to an airplane should come from a solid scientific basis," Hallam says. "You should know exactly why you're doing what you're doing." McManus sees that this rule is followed in the artifact's initial treatment, then he advises the staff about its ongoing care.

—Karen Jensen

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700; TDD: (202) 357-1729.

February 5 "Frontiers on Film" Series: *Innerspace*, a 1987 comedy starring Martin Short and Dennis Quaid. Langley Theater, 8 p.m.

February 6 Monthly Sky Lecture: "Astronomy from Space." George Carruthers, Naval Research Laboratory. Einstein Planetarium, 9:30 a.m.

February 10 Exploring Space Lecture: "Astronomy in the Time of Columbus." LeRoy Doggett, U.S. Naval Observatory. Einstein Planetarium, 7:30 p.m.

February 11 General Electric Aviation Lecture: "World War II Wasn't Fought in Black and White." Historian Jeffrey Ethell will show color slides taken during the war by servicemen and -women. Langley Theater, 7:30 p.m.

February 12 "Frontiers on Film" Series: *Marooned*, a 1969 space adventure starring Gregory Peck, Richard Crenna, David Janssen, James Franciscus, and Gene Hackman. Langley Theater, 8 p.m.

February 19 "Frontiers on Film" Series: *20,000 Leagues Under the Sea*, a 1954 dramatization of Jules Verne's classic. Langley Theater, 8 p.m.

February 23 Black History Month Lecture: Astronaut Frederick Gregory will describe his career as a pilot and shuttle astronaut. Langley Theater, 7:30 p.m.

February 26 "Frontiers on Film" Series: *The Goonies*, a Steven Spielberg production for children. Langley Theater, 8 p.m.

March 5 "Frontiers on Film" Series: *Indiana Jones and the Last Crusade*, starring Harrison Ford, Sean Connery, and River Phoenix. Langley Theater, 8 p.m.

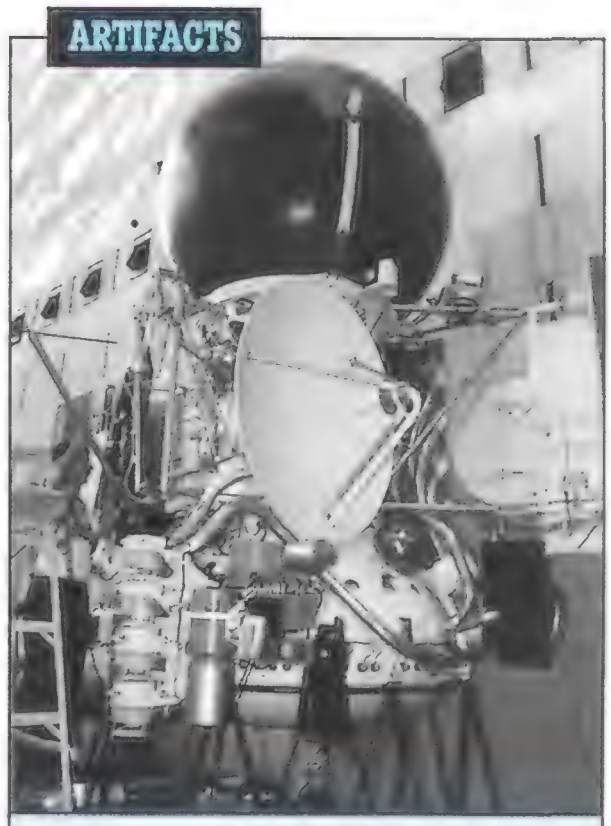
March 6 Monthly Sky Lecture: "Do Solar Radiation Changes Affect Earth's Climate?" Judith Lean, Hulburt Center for Space Research. Einstein Planetarium, 9:30 a.m.

March 11 General Electric Aviation Lecture: "Aerobatic Flying." Aerobatic champion Clint McHenry will explain his famous stunts. Langley Theater, 7:30 p.m.

March 24 Exploring Space Lecture: "Mapping the Universe." Margaret J. Geller of the Smithsonian Astrophysical Observatory will lead a tour of the universe with state-of-the-art computer graphics. Einstein Planetarium, 7:30 p.m.

Museum Visits For a free planning packet, write Smithsonian Information, Smithsonian Institution, Washington, DC 20560, or call (202) 357-2700.

ARTIFACTS



An engineering model of the Vega spacecraft, on a three-year loan from the Russian organization Glavkosmos, took its place in the Museum's Space Hall last December. The ultimate chase vehicles, two 4.5-ton Vegas left Earth in December 1984, dropped landers on Venus in June 1985, then took off after Halley's Comet, catching up with it in March 1986. The spherical shell (top) housed the Venus lander and a French-designed experimental balloon, a model of which is suspended above the Vega (see "Balloons Over Venus," June/July 1988). An instrument platform with 14 experiments continued on to Halley and relayed historic images of the comet's nucleus.

DC-6 HEAVY

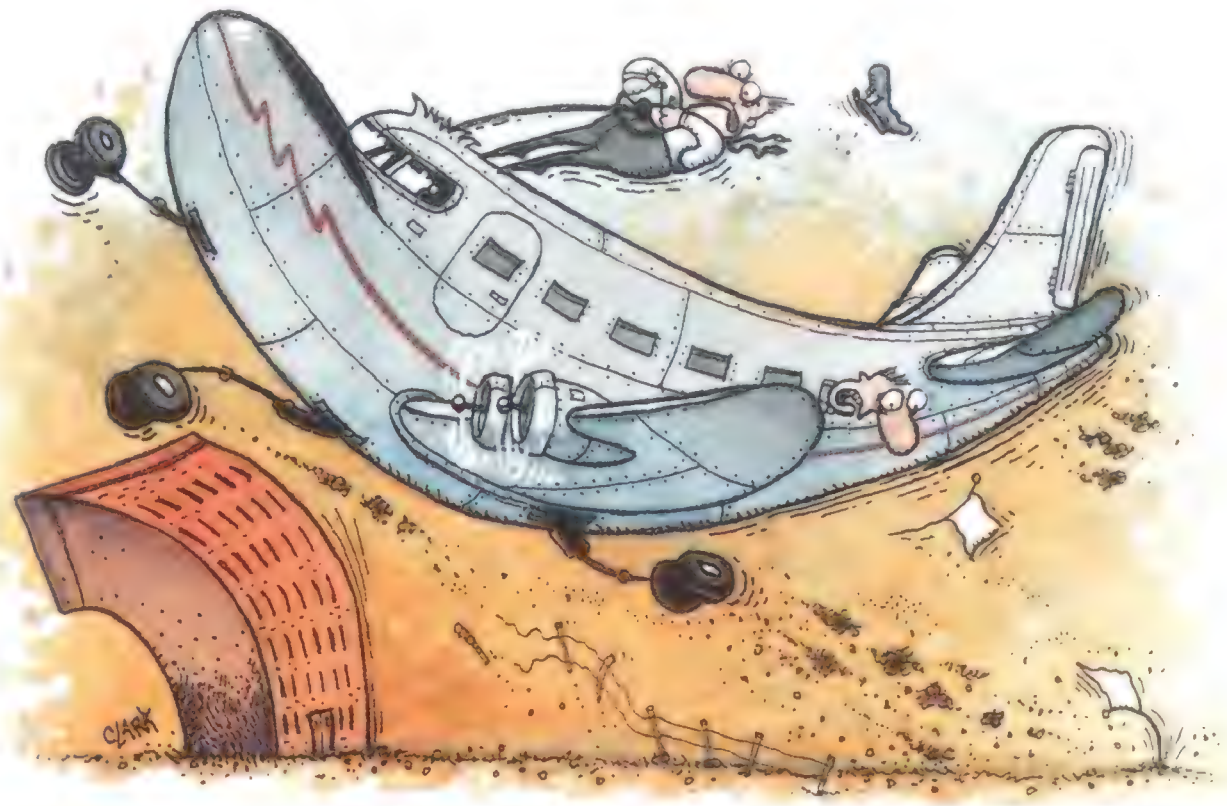
In 1951 I landed a summer job working as an engineer at American Airlines. American's engineering department was headquartered at La Guardia Airport in Queens, New York, which was a long drive from my home in New Jersey, but I didn't care. I was a year shy of earning my bachelor of science in mechanical engineering, and I was lucky to get the job. Most of my fellow students spent the summer working as lifeguards or mowing lawns.

The department was small: Frank Kolk, my immediate boss, was a brilliant man I grew to respect and admire during my short stay; he and Roy Hodson, both full-time engineers, worked for the division director, Harold Hoben. This small cast of characters played roles in one memorable episode that summer.

In late 1950, American had gotten some new Douglas DC-6Bs. During the winter the airline had also upgraded the performance of its older DC-6 aircraft by installing a water injection system on the engines. Injecting water into the air-fuel mixture helped boost the power available for takeoff, and in theory, the older DC-6s would now match the DC-6Bs. Using the charts developed during the DC-6B certification tests, American developed new charts for the DC-6s that increased the allowable gross weight at takeoff. Everything went fine—until summer came.

As the days got hotter, resulting in thinner air and increased takeoff rolls, pilots began to complain to the engineering department that the more heavily loaded DC-6s and -6Bs didn't accelerate on takeoff as rapidly as the charts said they should. Even with the strong southerly winds at La Guardia, pilots said the northwest-southeast runway was too short at high gross weight, so they began using the longer southwest runway. But the DC-6 crews continued to complain about performance. Part of the problem was attributed to the water injection system, unique to American's engines and later found to be inferior. But the strong crosswinds on the southwest runway also impaired takeoff performance. Hoben's operational engineering department didn't take these complaints too seriously because a check of the performance curves showed that both airplanes were certified for takeoff at the gross weights used on runways as short as La Guardia's, even with one engine out.

As the summer dragged on, it got hotter with each passing week. One day in July the temperature neared 100 degrees, and probably higher on the runway. That afternoon a senior DC-6 pilot, white-haired and red-faced, stormed into the engineering office. Kolk happened to be standing at my desk when the angry pilot confronted him. "...and I damn near didn't make it over the apartment building about a mile off the end of that runway!" he howled. "Now what are you guys going to do about it?"



DAVID CLARK

Hoben and Hodson were drawn into the fray, and soon the whole thing turned into a shouting match. The pilot was adamant that all four engines had been perking along normally, the takeoff settings for the propellers, flaps, and cowlings had been checked, and every one of the items on the takeoff checklist had been verified, "but the damn plane just wasn't about to leave the ground," he said. "Hell, I was past the last taxiway before she broke ground, and I damn near hit the fence at the end of the runway. Now something has to be done about this, 'cause I flat out am *not* going to make that run again with that gross weight. *Period!*"

When an experienced senior pilot throws down the gauntlet like that he can't be ignored. This was serious, and Kolk knew it. Apparently, something was very wrong with the takeoff performance of the DC-6s and possibly the -6Bs as well. At this point Glenn Brink, the chief test pilot, was called in to join the meeting, which was still proceeding at my desk. He promised the disgruntled pilot that he would thoroughly investigate the incident and get to the bottom of the mystery.

The flight had been scheduled

nonstop to Dallas at a gross takeoff weight of 89,000 pounds, which in those days was considered heavy. Brink decided to test the takeoff of the DC-6 using the same runway the Dallas flight had used and under the same conditions.

Kolk sent me out on the runway with a tape measure and two white flags attached to wooden stakes. I was told to plant one of the flags at the edge of the runway where the charts said V_1 should occur during the takeoff roll. (V_1, for a multi-engine aircraft, represents the speed at which the pilot, upon losing an engine, must decide between aborting the takeoff and braking to a stop or continuing the takeoff on the remaining engines.) The second flag would be planted at the point where the airplane should achieve V_2, or minimum takeoff speed with one engine out. A DC-6 was topped off with fuel and ballasted with sandbags strapped in the passenger seats and the baggage compartment to produce a gross weight of 89,000 pounds.

We didn't have to wait long for another 100-degree day. When it came, I was invited along for the ride.

My job was to sit about halfway back in the cabin holding an Aldis light, which would produce a powerful strobe-like flash when triggered by the cockpit crew as the airplane reached V_1 and V_2 speeds. A special Fairchild motion picture camera mounted a considerable distance from the runway would record the flash and thereby the time and distance for use in making calculations later.

American had me sign an accidental injury and death liability release of some kind, and I excitedly climbed into the airplane and took my position. Kolk decided to observe the takeoff from a position near the V_2 flag. Glenn Brink took the left seat in the cockpit as pilot in command, and Captain Walter Braznell, Brink's boss and head of American's flight department, flew copilot. They ran a wire from a switch in the cockpit to my Aldis light and closed the door. I was all alone. It was eerie sitting in a cabin in which all the other seats were occupied by sandbags. I think it was about then that I began to feel a little nervous. The unbridled fear and sheer panic came later.

The plan, which I had not been briefed on, was to make the first takeoff at gross weight to observe a "normal" four-engine takeoff, which was the very condition being questioned. On the second takeoff, Brink and Braznell would cut an outboard engine at V_1, continue on three engines to V_2, then lift off and climb out at minimum climb speed. The book said we *should* clear any obstacles even at these high temperatures.

We taxied out and lined up for takeoff. I pointed my light in the direction of the camera and the cameraman, tiny specks in the distance. Brink went to full throttle and released the brakes, and we began to rumble down the runway. We were not accelerating as fast as I had expected, but I concentrated on keeping my light pointed at the camera. The camera slipped out of view just as the V_1 flag passed—slowly, it seemed to me—and still the Aldis light did not flash. Now I was pointing the light quite far to the rear, and anxiety began to well as the seconds went by. Out of the corner of my eye I saw the V_2 flag come into view. Still no flash.

My God, I remember thinking, *it's just like that angry captain said: we're way behind on our takeoff speed.* I watched as the V_2 flag neared. Just then the Aldis light flashed—we had reached V_1 speed—and almost immediately the V_2 flag drifted past my window. After that, we just droned on. The Aldis light remained dark and I could no longer see the camera, so I just pointed the light and watched.

The last taxiway was coming up fast. The runway ended almost immediately past it. I could see the cyclone fence that marked the boundary. "Aw come on airplane, *fly*," I begged.

Just then the nose came up and I could hear the gear retract as we clawed for altitude. Like the angry captain, we barely cleared a high-rise apartment building about a mile from the runway. After that I started breathing again. I also realized that the light never did flash for V_2—in the excitement, the crew had completely forgotten about it.

Later, Brink and Braznell said that it had become obvious that the airplane was not performing as predicted. They seriously doubted they could complete a takeoff with an engine cut at V_1. But the second takeoff would be proof positive.

We flew around for a while to burn off fuel, then Brink greased the airplane in for a feather-light landing. But nobody emerged from the cockpit when we taxied back and refueled, and I began to feel uneasy. Then we headed back out to the runway. We were going to do it again! If I had known Brink's intentions, I'd have gotten off.

We repeated everything up to the flash of the light at V_1, and at that instant Brink cut an engine. We began to decelerate and the airplane started shaking. We were in trouble.

Brink later explained that at the point of engine cutoff, the airplane was below the speed at which the rudder could control it, so he had the stick pushed forward to keep the nosewheel on the runway and was steering manually with it. This created a side load on the nosewheel, and it began to chatter.

Fortunately Brink had only throttled back rather than shutting the engine down. He shoved the throttle forward almost immediately and the airplane resumed its lumbering takeoff. This time we cleared the fence by an even smaller margin, but we landed without further incident and shut down at the company ramp.

The cabin door swung open. Both pilots walked straight to the exit door without saying a word. Brink glanced at me and smiled, but his face was white as a sheet. I'm sure I was pretty pale myself. Whatever they discussed back in the office was kept private; nobody said anything to me.

The next day Kolk brought me a plate from the Fairchild Flight Test Analyzer and the record of the second flight test and asked me to reduce the data. The camera, still experimental, had a moving lens housing that tracked the subject, recording images on a glass plate. The final image was a series of vertical strips showing the position of the nosewheel and a clock that recorded time in thousandths of a second. My job was to measure the distance between the nosewheel marks, convert that into feet along the runway, and, using the clock times, plot the time-distance curve of the takeoff. From that I could calculate the velocity-distance curve and thus the acceleration.

On closer examination of the plate, it was apparent that this was going to be tricky. My first plots were all over the place, and even after I reduced the scatter the acceleration curve turned out to be a straight line. What little acceleration there was stayed hidden in the thickness of the pencil line I had made drawing the "curve."

The effect of temperature had never been fully taken into account in the calculation of takeoff performance. It was not until the advent of jets that this and several other conditions were factored in to the regulations affecting takeoff performance and allowable gross weights at takeoff.

This DC-6 flight test would prove to be a milestone in the learning of this lesson. Soon afterward, tests were performed using a DC-6B in Palm Springs, California. They revealed that Douglas and the Civil Aeronautics Authority had made serious errors in the calculations at the high gross weight and high temperature ends of the scale—the conditions prevailing when flying "heavy" out of La Guardia in the summer. The DC-6B was quietly recertified, and American adjusted the performance charts for the DC-6s. Our disgruntled captain went back to flying his nonstop run to Dallas, but at considerably reduced gross weight.

—William C. Walter

BACK IN THE SADDLE

I've managed to find the shutoff switch on my travel alarm clock and begin the process of waking up in a strange hotel room far from home. In a way, I have become very much like the airplanes I fly, needing to initialize my internal gyros with position, heading, and time before I can function properly. Gradually I stow the mental filters that helped me sleep, get my bearings, and adjust to my surroundings, which are, paradoxically, familiar by their unfamiliarity. I think it's Thursday.

For the past few years, my world has been a succession of hotel rooms, climates, and cuisines linked by hour after hour in the cockpits of Gulfstream IV business jets. The address on my business card is a pager number where clients can reach me instantly if I am in a fair-size U.S. city or leave a message if I am out of the coverage area—on the beach at Las Palmas, say, or hopelessly lost (along with my taxi driver) on the streets of Karachi. You might say I live in a little black box that clips to my belt. It's peaceful most of the time, but occasionally my little house beeps and I launch myself to who knows where for who knows how long. I think it's a neat way to make a living; my wife hopes it's a phase I'll outgrow.

Padding around my hotel room, I remember that as a child I wanted to be a cowboy. Not just any cowboy—I wanted to be Roy Rogers, riding to the rescue. Then I discovered that horses have minds of their own and preconceived notions of who is boss. They also bite, kick, and sulk. I decided that if I had to ride to the rescue on horseback, there wouldn't be a whole lot of rescuing going on.

Fortunately for me, out of the clear blue western sky came the TV show "Sky King." Airplanes are a lot different from horses. They don't bite, kick, or sulk unless sorely wronged by pilots or mechanics, and, with a few exceptions, they don't sit around the hangar plotting nine ways to kill me. So I decided against horses and took up flying. Pilots and cowboys are a lot alike, but pilots don't have to sleep outside on the ground.

Continuing my wake-up routine, I spend a few minutes separating fantasy from fact and confirm that this is Caracas, Venezuela, it's 2:30 on a Friday morning, and I have 45 minutes to shower, shave, dress, pack, and check out before my ride to the airport. A fax is waiting at the front

RICHARD A. GOLDBERG

desk with my flight plan and weather briefing for the flight to New York, on which I will serve as a relief captain. This has been a typical stint: Rome to Luton, England, to Atlanta to Miami to Caracas, and now to New York. After four days there, during which I will be retained on call, I am scheduled to fly back to Caracas, where I will be relieved.

At the airport, awaiting my airplane's arrival in the shelter of the customs office, I reflect on a time when I had a real flying job. The company had owned airplanes for over 50 years, and I thought I would have a job until retirement. Then came the rustlers in their power ties, riding over the hill in their BMWs, briefcases in hand, waving papers announcing a leveraged buyout. The flight department never had a chance. I packed my bag and hit the trail as a modern-day Paladin (Have Airline Transport Pilot Rating, Will Travel), a contract pilot.

My airplane has landed and I have mustered the fuel truck and ground service personnel. The captain I am relieving briefs me on the condition of the airplane (good) and last-minute changes to our schedule, which include the possibility of an earlier return. We are off to New York 28 minutes from the time the parking brake was set after landing, a respectable turnaround.

Seven hours later, in my next hotel room, I have completed my paperwork and debriefed the flight. The curtains are drawn and I am ready for a nap to bring my body clock closer to normal.

My profession is a fragile one. Any number of events could end my career: a heart that ticks when it should tock, a human mistake, an element of chance. Though I try to prolong my professional life, one of these days I will hang up my Jeppesen charts and call it quits. Drifting off to sleep, I am mellowing, thinking of becoming a line pilot again, a hired hand in a stable of hired hands. My wife would like it, I know, and I'd like to have a house to putter around in. I miss my children and grandchildren. I want another dog.

But there are airplanes to fly, places to go, people to meet. I don't know it yet, but next week my beeper will go off and I will fly to France and Switzerland, my sixth Atlantic crossing in two weeks. It will beep again before I reach home and the buyer of a used airplane will need a crew until his pilots are trained.

I'm a lucky man. I've made a lot of friends and been helped along the way by some fine people. If you are one of the next generation of pilots, work hard and learn all you can. Someday a saddle-sore pilot will hand you a little black box that clips to your belt and beeps, calling you to who knows where for who knows how long. Hopefully often.

—Alex Nelon

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An Industry Held Hostage

Airlines continue to wage a war against terrorist attacks, but there's still little light at the end of the tunnel.

by William Triplett

Photographs by Christopher Springmann

In August 1982 at Budapest's Ferihegy Airport, a big, beefy, and very nervous 40-year-old Palestinian named Adnan Awad handed his carry-on luggage to airport security officials and prayed he would be found out. Hidden inside his large tan garment bag was a bomb, and in his shoulder bag a detonator. Both bags passed through X-ray without raising the slightest alarm. Then German shepherds, trained to sniff for explosives, pounced on the bags. Awad, the reluctant terrorist, felt his hopes rise. But eventually the animals turned away without even a growl. The security officers wished him a pleasant flight.

As his airplane touched down in Zurich an hour or so later, Awad began to put his faith in the Swiss. "They are such a high-technology society. I was sure they would find it," he says as he lounges on a sofa in a split-level brick house somewhere in the American heartland. Until recently he was a member of the federal witness protection program. Today, wearing blue jeans, a sweatshirt, and a baseball cap, he asks his visitor to join him for Arabic tea. At least two dozen firearms are conveniently situated around the room.

Awad finally decided to turn himself in at the U.S. embassy in Bern, Switzerland, and tell authorities where to find the bomb. But even then, Swiss police could not find the explosives, which had been sewn into the seams of his suitcase. Abu Ibrahim, the bomb maker and the head of 15 May Organization, a radical faction of the Popular Front for the Liberation of Palestine, had been true to his word. The thing was invisible.

For counterterrorist experts the implication of the bomb's invisibility was the latest chilling evidence that the civil aviation security system was vulnerable in a way it had never been before. The whole equation had changed.

Like Wile E. Coyote, terrorists once favored the TNT-and-alarm-clock variety of bomb; today they use paper-thin sheets of explosives known as plastic (or *plastique*). Roughly twice as powerful as conventional dynamite, these explosives are called plastic because they can be molded into any shape, making them virtually undetectable to existing technology. And the vapor

they release is so thin that bomb sniffers, at least the noncanine variety, have a hard time detecting it. Invented by the British during World War II, plastic explosives didn't become part of the terrorist arsenal until the 1980s. But by mid-1985 the body count from exploding airliners was over 500 and plastic explosives had been involved in a number of the bombings. (The total would have been even higher had not several bombs been discovered by sheer luck.) The type most commonly implicated in Middle Eastern terrorist attacks is Semtex, a brand manufactured in Czechoslovakia. Awad's bomb was made with Semtex.

Despite the fact that terrorists had planted explosives on 15 aircraft around the world between 1980 and 1985, U.S. airline security remained basically unchanged since being upgraded in 1973 in response to a high incidence of hijackings. The prevailing theory continued to be that terrorism was largely confined to the Middle East and Europe—or at least didn't involve the United States. That changed on June 14, 1985. Shortly after taking off from the Athens airport, TWA flight 847 was hijacked by terrorists who left no doubt they were paying back the United States for its failure to condemn Israel's invasion of Lebanon three years earlier. Over the course of 17 harrowing days the airliner shuttled back and forth between Beirut and Algiers until the hostages were all finally released, with the exception of U.S. Navy diver Robert Stethem, who had been brutally beaten and shot. Suddenly the industry took note of the implications. "A colleague of mine made a comment that going forward we would refer to everything in aviation security as either before or after that date," says Billie H. Vincent, director of the Federal Aviation Administration's Office of Civil Aviation Security from 1982 to 1986. Airline industry insiders realized that the United States was now considered as likely a target for terrorists as Israel. Awad's experience in Baghdad with the leader of the 15 May group confirmed this new status of the United States: "Mostly [Ibrahim] was mad about Pan American; he mentioned it many times," he says. "I think just because of the name—it had 'American' in it."

Following the hijacking of TWA flight 847, the FAA promptly tightened the security system with a mix of measures old and new. The moribund Sky Marshal program, which consisted of both uniformed and undercover security officers riding aboard airliners, was revived at the suggestion of a then-unknown Marine named Oliver North,

who was working at the National Security Council. The FAA also launched a long-term recruiting drive to beef up its security staff from roughly 200 to an eventual total of 800. Most importantly, new standards for luggage screening now required a baggage-passenger match. All interlined suitcases—those bags that were being transferred from one airline to another—would have to be matched with a passenger who could be accounted for, the theory being a terrorist's dedication did not extend to suicide. Any bags that could not be matched would be pulled, opened, and searched before being loaded.

"There was a lot of tension then," remembers Arik Arad, former director of security for Israel's El Al Airlines at Ben-Gurion International Airport in Tel Aviv and now chief executive officer of International Consultants for Targeted Security in New York City. "Many of us [in the aviation security community] had very bad feelings that something big was going to happen." It did. On December 21, 1988, Pan Am flight 103 exploded at 31,000 feet over Lockerbie, Scotland, killing all 259 people in the airplane and 11 others on the ground. In the aftermath of the tragedy the families of the victims called for an investigation of the entire aviation security system. They got it in the form of the President's Commission on Aviation Security and Terrorism, a seven-member committee chaired by former labor secretary Ann Dore McLaughlin. Seventeen months later its report said that authorities had concluded that a copper-colored Samsonite suitcase on board Pan Am 103 had contained a Toshiba radio-cassette player with concealed plastic explosives. The bomb had been timed to explode when the flight was over the ocean, but a tardy departure left a swath of evidence spread over 800 square miles of Scotland. The report was not able to determine exactly how the suitcase containing the explosives got aboard flight 103, but it cited Pan Am for simply X-raying luggage (X-rays cannot always detect plastic explosives) instead of matching interline baggage with passengers. The report also mentioned a container of luggage that was left unattended for half an hour at Heathrow Airport in London before the luggage was loaded aboard 103. (The U.S. Department of Justice has indicted two Libyan agents for the bombing. It is now widely believed that the airplane was bombed in revenge for the 1986 U.S. bombing of Tripoli, which killed Libyan leader Colonel Muammar Qaddafi's adopted daughter.)

Even more devastating, however, was the 182-page report's searing indictment: "[T]he U.S. civil aviation security system is seriously flawed and has failed to provide the proper level of protection." The commission concluded that the FAA had learned few, if any, lessons from the Pan Am 103 bombing. It documented flaw after flaw in everything from security training procedures to explosives detection technology.

The recommendations of the commission formed the basis of the Aviation Security Improvement Act of 1990—Congress' response to the commission's report and the blueprint for the antiterrorist system in place today. According to a statement issued in 1991 by then-Secretary of Transportation Samuel Skinner, 46 actions required by the new law are scheduled to be in place by 1993. They include federal security managers installed at 18 major U.S. airports, more stringent requirements for airport and airline security workers, and a new push to increase the number of FAA security staff to 1,000 by the end of this year.

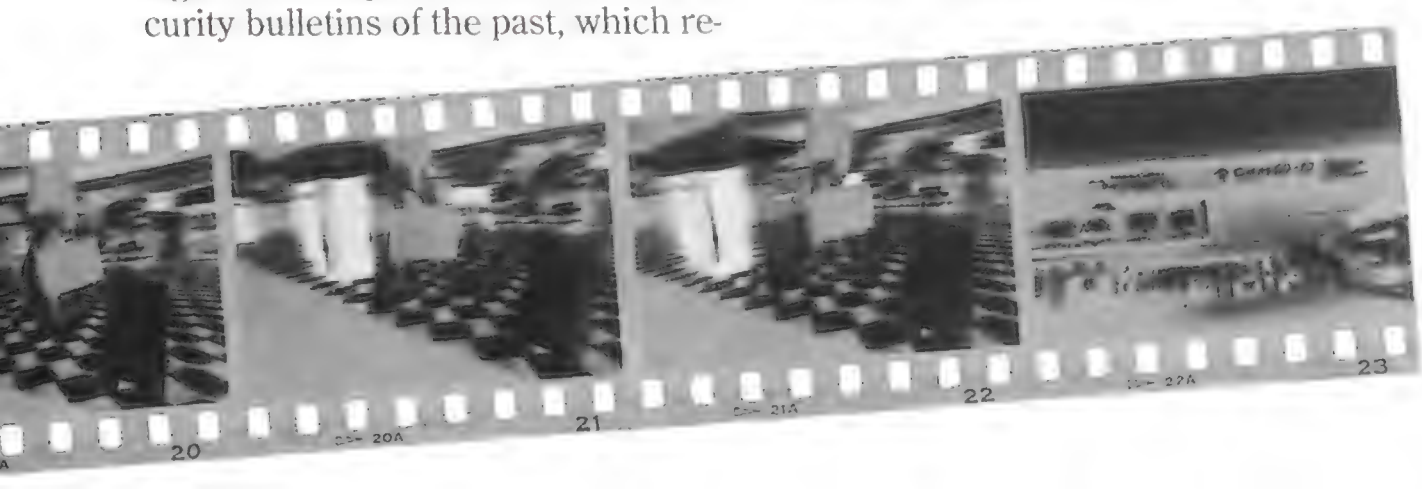
The commission report also led to the creation of the Department of Transportation's Office of Intelligence and Security. If there is a single determinant of airline security, it is intelligence. In theory, officials will try to supply enough security to meet the threat, which it is the job of intelligence to identify. The OIS, which reports directly to the secretary of transportation, constantly reviews "reams and reams of intelligence flow," according to its director, retired Coast Guard admiral Clyde Robbins. Along with the FAA's intelligence division, which was created in 1986, the OIS reviews the data in search of security threats. If clear and present danger is seen, the FAA puts the airlines on notice with a security directive, which requires a written acknowledgment within 24 hours and details of actions to be taken to meet it. This is a significant improvement over the security bulletins of the past, which required no response.

Both the OIS and the FAA depend on the intelligence community for their data. In the United States, responsibility for dealing with terrorism is parceled out primarily among the Central Intelligence Agency, Department of State, National Security Agency, Defense Intelligence Agency, Federal Bureau of Investigation, and Department of Justice. The National Security Council is also involved at a policy level. To coordinate all the counterterrorist efforts by the various intelligence agencies, the CIA's Counterterrorism Center (CTC) was set up in 1986 as the government's central nerve system in the fight against terrorism. According to Vincent Cannistraro, former chief of counterterrorist operations for the CIA, the CTC was the brainchild of former CIA chief William Casey, who had become obsessed with stopping the humiliation that terrorism was heaping on the United States throughout most of the 1980s.

In the beginning, however, the CIA's old guard objected to the gritty nature of the mission. "It was not at all like being a gentleman spy in pinstripe suits working embassy cocktail parties," says Cannistraro.

The CTC's intended mix of operations people and analysts—spies and eggheads, as it were—worked uncomfortably close to each other. "You had the world of thought and the world of action coming together when there had always been a wall between the two in order to protect the objectivity of the intelligence product," says Cannistraro. "But you had to mix them because terrorism doesn't wait. You're not talking about trends over the next six months. Lives are at stake." It wasn't until Pan Am 103 exploded, he says, that the CIA finally started taking aviation terrorism seriously.

The CTC's internal battles were merely a microcosm of the larger turf wars then raging between different agencies. "The problem throughout the '80s was



that the White House would not take any responsibility," says Noel C. Koch, formerly the Pentagon's chief counterterrorist official and now head of a security consulting firm. "The people who would have had to take responsibility were schooled in the Iran hostage years, and they understood that terrorism is a political loser." As for the various intelligence agencies, he says there was no first among equals. "They all saw themselves as first, and if they didn't want to cooperate with each other they didn't...," says Koch. "Nevertheless, the state department [as the designated lead agency] tried to sit on this disjointed horse and ride it."

Fortunately, the president's commission found that by the end of the 1980s the internecine hostilities had subsided and information sharing among the intelligence agencies was finally at a premium. "There is a very tight-knit, coordinated effort within the government now," says one Pentagon source. "Everyone knows that when the threat is there, we all need each other."

But security efforts continue to be limited by the intelligence community's ability to develop information on terrorist operations. "It stinks," says Koch. "Terrorism intelligence is bad in general. It's particularly bad on aviation terrorism, and the reason is that it's all organically predisposed to be bad." What he means is that terrorist groups—particularly Middle Eastern ones—tend to be small, clannish organizations that can be all but impossible for agents to penetrate. Membership in the pro-Iranian group Hezbollah, for example, almost requires some type of family connection. Outsiders wishing to join must prove themselves. Lawrence B. Sulc, a retired CIA operations officer, offers a hypothetical example: "They'll take you driving and slowly come around a corner, see an old lady in her garden, and tell you to shoot her. If you don't, you die." The alternative puts the U.S. government in the indelicate position of employing murderers.

Even if an agent can be placed, chances are he'll be unable to get information out. "You're not allowed to make phone calls or meet anybody," says Sulc. Moreover, things often change at the last minute. TWA flight 847, for example, was the hijackers' second choice. The final selection was made inside the airport terminal.

Ultimately, intelligence on terrorist operations requires reading a database like tea leaves—it depends on a computerized knowledge of the past combined with a human ability to read "preincident observables," as they're called, in the present. What can seem like random events in random locations—a string of bank robberies here, a rash of passport thefts there—may be a certain terrorist group's usual precursors

to buying explosives and moving people into position. Deciphering things requires "sustained microanalysis, 24 hours a day, seven days a week, by someone who's finely tuned to a particular group," says the Pentagon source.

For the airlines and airports—at the tail end of the intelligence chain—the situation is even less certain. "The FAA tells us there is a threat," says Art Kosatka, security director for the Airports Association Council International, "but when we ask what it is exactly, they never say. Nobody can really define what it is." And that means the appropriate level of security is always in question. Admiral Robbins concedes that "the final decision on [the necessary amount of] security often comes down to a gut feeling."

Even with proper intelligence it's difficult to protect airplanes. "By their own technology airliners have built-in vulnerabilities," says Robert C. Quigley, former head of the FBI's bomb data center. "The good news is that over the last 15 years a lot of different elements have been added to the system that make it more difficult for terrorists to attack an airliner. But airliners are extremely attractive because of their vulnerabilities. They will always be targets."

As Adnan Awad discovered, screening provides aviation security with its

main line of defense. Its complementary components are still a metal detector and X-ray machine. The quality and capability of metal detectors have improved over the years, making it more difficult to smuggle common guns and knives on board. Most security experts, however, consider the X-ray machine to be the most important tool, since the greatest threat continues to be the checked suitcase. But the reliability of X-ray continues to raise questions. "What people forget is X-ray was brought in originally to find hijacking weapons, not bombs," says Quigley.

The president's commission report concluded that the FAA had failed to develop adequate technology in response to the threat of terrorism. Following the Pan Am 103 bombing, a host of congressmen demanded better airline security, which led to the deployment of a detection system known as thermal neutron analysis, or TNA, which uses radiation to look for the nitrogen in explosives. The massive units weigh 10 tons each and cost $1 million apiece. The first was installed at New York City's John F. Kennedy International Airport in September 1989, and others are now operating at Washington's Dulles International Airport and London's Gatwick Airport. Two are planned for San Francisco and one for London's Heathrow Airport.

The commission report, however, recommended that the FAA defer its decision to force airlines to buy thermal neutron analyzer machines. The machines tend to miss small bombs, plastic explosives, and non-nitrogenous bombs, and when adjusted to search for small bombs, the machines produce an excessive number of false alarms. Spurred on by the commission report and Congress, the FAA has been testing other methods. With about three times the budget and four times the staff it had before Pan Am 103 exploded, the FAA's aviation security R&D service has awarded more than two dozen contracts to research other screening methods. This work includes testing other nuclear techniques that might eventually replace TNA devices. Fast neutrons capable of detecting elements

The Bomb-Resistant Airliner

If bomb detectors can't be made foolproof, why not make airplanes bombproof? That's the latest strategy in an effort to make the skies safe from terrorism.

The easiest solution might be to harden the removable luggage containers of commercial airliners so that they can withstand a bomb blast. The FAA is researching this strategy, and bomb-resistant luggage containers might be available for use in wide-body airplanes within several years. One manufacturer has developed a container to be lined with a blanket made of high-strength composites. The blanket is strong enough to protect the aircraft from the debris of the blast, yet porous enough so gases from the explosion could slowly escape without damaging the aircraft. The container also releases powder to prevent a fire.

A more radical design is a container that could cut a hole in an aircraft's fuselage to vent an explosion overboard. Metallic cutters would open a precise hole that would allow gas from the explosion to escape and the aircraft to fly to safety.

Hardened luggage containers would probably be used in conjunction with bomb detectors. The idea is that detectors would keep large bombs off airplanes and hardened luggage containers would make airplanes impervious to the small bombs that detectors currently cannot detect.

Another solution is to harden the entire aircraft. The obvious drawback to this approach is increased weight. Airlines and aircraft makers, which are opposed to any designs that add weight (and costs) to an airplane, favor bomb detection devices.

Retired Coast Guard admiral Clyde Robbins, director of the Department of Transportation's Office of Intelligence and Security, thinks bomb-proofing airliners shows promise. He admits he was skeptical at first. "My first reaction was 'Sure...,' but I have seen some really promising technology since then." He adds, "Of course, our first priority is to keep explosives off airplanes."

besides nitrogen are one possibility. In addition to other nuclear techniques, more advanced X-ray systems are also being tested. X-rays don't actually detect explosives, but instead offer an imaging system that enables operators to identify bombs. One manufacturer has developed an X-ray system based on computer-assisted tomography, the same technology used in medical CAT scanners. Chemical devices are also being considered, perhaps the most promising being vapor detectors that attempt to duplicate with technology what dogs traditionally have been trained to do.

But the grim reality is that terrorist R&D has continued to outpace counterterrorist technology. "The sophistication of terrorists today is such that none of the machines available would cover all the weapons and explosives terrorists have," says Arik Arad. Which may be why the Congressional Office of Technology Assessment recently recommended that a combination of the latest technologies may be much more effective than any single method.

"[The FAA was] letting the ability of the existing technology dictate what the standard should be, rather than asking 'What new technologies do we need to develop to see this thing?' " says Quigley. "That question is only now beginning to be asked. There's been no progress on it yet."

Even a machine that can see all, know all, or sniff all is only going to be as effective as the person operating it. "Screening can be the most effective weapon you have," says Hector Gonzalez, who spent more than 20 years as an FAA

security officer, "but it is also the weakest link because that's where the human element comes in." Air carriers have generally elected to contract with private security firms for screening. A boring job that often pays little more than minimum wage, screening is a profession that generally suffers from poor motivation. In 1987 Gonzalez led an FAA team into airports across the country to test screeners and found that more than half the test objects were getting past them. "They were not paying attention, just talking to other people," he says. (The FAA now requires that new detection systems automatically alert operators to possible threats, a compensation for human fallibility.) Complacency is also a problem. "The screeners had gotten used to seeing the same people come service the aircraft every day and stopped bothering to check them," says Gonzalez. While airlines are responsible for screening passengers and luggage, airports are responsible for ensuring that only authorized people are allowed beyond the boarding gate. In December 1987 a recently fired USAir employee made a mockery of airport security when he breezed through a checkpoint at Los Angeles International Airport and boarded a commuter jet. After takeoff the man took his revenge by shooting the crew, causing the airliner to crash, which killed everyone aboard.

The president's commission took grave notice of the problem: "FAA has paid little attention to how to recruit, train and motivate a security work force...," it observed. This prompted a government press release in response: "FAA has adopted more stringent requirements for the employment, training and performance of airline and airport security officials." Yet sometimes screening becomes a game of sorts. "The screeners are taught to be on the lookout for the weapons on the FAA's test list," says Quigley. "What happens is, that's all they look for because they know if one of those gets through, the company is going to get fined. So the mission has become: prevent the fine."

Kenneth Moore, a former head of security for United Air Lines and the author of a book on commercial aviation security, acknowledges that much has improved, but he contends that a lot more can be done. "Some airlines are still going to the bottom of the labor pool," he says, "and some are still contracting their guard services on the basis of the cheapest bid."

It should come as no surprise that security—that is, human life—has a price. Commercial air travel is, after all, a business. Despite their public declarations, says Moore, the airlines haven't totally stopped pursuing security "in the cheapest way possible." Frank G. McGuire, editor of *Security Intelligence Report* and author of two books on terrorism, concurs. "There is better technology available," he says, "but the airlines don't use it because it's more expensive."

Airline officials, however, insist that safety is a paramount concern. "Everyone still has to watch bottom lines," says Tom Kelly, managing director of security for the Air Transport Association, the airline industry trade group. "But I guarantee you, if you weigh security against budget concerns, security is going to win every time. The airlines are very serious about security."

Israel's El Al is often recognized as the best defended airline in the world. The airline insists that passengers arrive three hours before departure, questions them repeatedly, searches every bag, and in short disregards any semblance of what we

call civil rights. This heavy-handedness has paid off. In April 1986, a young, very pregnant Irish woman named Ann Murphy prepared to board El Al flight 016 to Tel Aviv at London's Heathrow Airport. Her bags cleared X-ray screening but Israeli security officials continued to question her before boarding; her answers didn't seem quite right. They dumped the contents of the bag her Palestinian fiancé had given her onto a table, lifted the bottom out, and found some three pounds of Semtex, roughly four times what is thought to have brought down Pan Am 103.

Yet El Al is also heavily subsidized and has only 20 aircraft. "Israel doesn't have an airline," says Noel Koch. "Israel has a hobby." Arik Arad believes El Al's measures could be applied to virtually any airline, but Moore asserts that as a result "traffic in the U.S. would come to a halt."

Cargo and mail offer additional routes past security. The week before an Air India 747 disappeared into the ocean off the coast of Ireland in 1985, probably the result of a bomb in the front cargo hold, authorities at New York's Kennedy Airport received a call saying a bomb had been placed on an Air India jumbo jet preparing to depart. The FBI was brought to the scene. "They took 300 people off the airplane, brought sniffers on, and took everything apart for the next seven hours," says Quigley. As the weary bomb squad started to comb through the cockpit, a cargo container was hauled up to the aircraft outside. The Air India official told the FBI agents not to worry. It was only cargo that had been held at the airport for 24 hours; such cargo is routinely loaded into airplanes uninspected. (No bomb was found, but Quigley says the team got depressed by the futility of it all.)

The theory used to be that if cargo, which in 1991 accounted for $5.5 billion of airline revenues, was held at the airport for a full day before departure, any bomb would explode in the warehouse. With timers capable of month-long delays now available from any electronics shop, some airline security representatives have suggested that all cargo be screened. Many, including Art Kosatka, consider this unrealistic. "You don't have the real estate or the manpower to tear [uninspected cargo] apart and put it back together," he says.

For international cargo, the primary security measure has been the "known shipper" principle, which releases carriers from screening anything if they've dealt with the shipper long enough, presumably, to know he would never do something so unprofessional as stick a bomb in a crate. The commission report, unhappy with the numerous security lapses surrounding airline cargo, urged the FAA to "foster a research program to provide technological solutions necessary to screen bulk cargo, as well as checked baggage."

When it comes to the U.S. mail, which brings some $1 billion a year to airlines, federal privacy laws prohibit any screening. Security generally involves merely restricting access to the mail processing areas. A terrorist could still conceivably mail a bomb from any post office. During the Persian Gulf war, when Saddam Hussein was calling for terrorist attacks on Americans everywhere, the Postal Service tried to close at least one security hole by banning U.S. airlines from carrying any parcels weighing more than one pound. According to Dick Shreve, assistant director of cargo services for the Air Transport Association, the ban cost the airlines about $300 million in revenues at just about the time the recession was starting to strangle the industry.

"There are holes in the security system you could drive a 747 through," says McGuire. "Mail is just one of them." Bill Jackson, assistant professor at the Center for Aerospace Science at the University of North Dakota, told the newsletter *Airport Operations* last year that the difficulties stem from the overwhelming challenge of trying to protect an airport, which he contends "a Marine rifle battalion couldn't completely secure." One small example that Kosatka cites is the caterer's truck that delivers food to the aircraft. "I'm going

to check everyone's [I.D.] card on that truck, sure," he says. "But nobody's got the time to look inside the truck. Nobody's going to look to see if there's a bomb under the scrambled eggs."

Neither government nor industry pretends that the system is foolproof. "You'll never have 100 percent security," says Admiral Robbins. "As soon as you apply pressure in one area, another area becomes weak as a result." He believes, however, that the system will always cover its weaknesses when it counts. "There's also a lot more security than meets the eye," he says.

But does that really account for the relatively good security record of U.S. airlines? Even Kosatka, who has every reason to assure the public that the airport security system he represents is truly effective, admits he doesn't think so. "Every now and then somebody repeats the inside joke of the industry," he says. "You paint a cardboard box black, put some terrific lights on it, put a cop at each end, you run everybody and everything through it, and people are going to think everything's been screened. As long as you don't tell them it's useless, it's a tremendous deterrent because of what you see—the flashing lights and two cops."

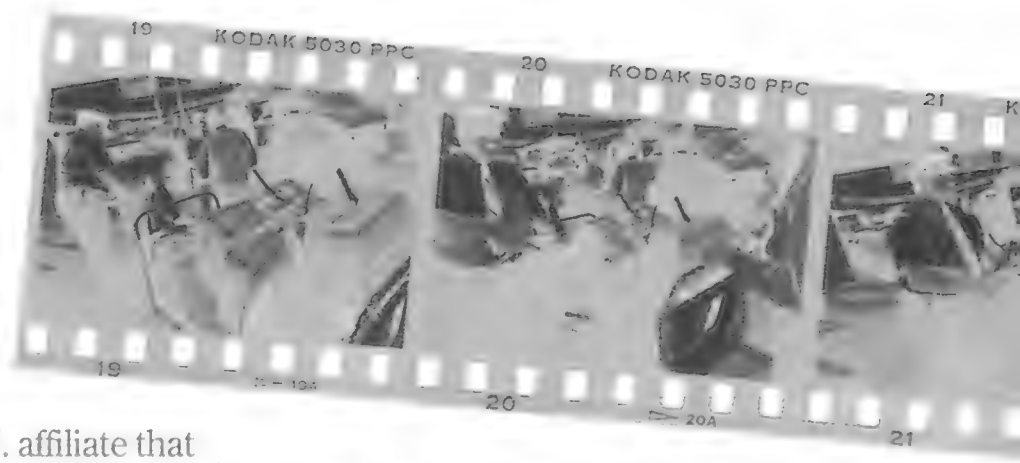
"The system looks a lot tougher than it really is," agrees McGuire. He says it's important to keep in mind that "very few people are actually trying to get bombs on airplanes. When they do try, they usually succeed."

Then why aren't more airplanes blowing up? Probably because, despite the normally extensive preparations terrorists make for an attack, much of their success still depends on chance. "The challenge is not getting the bomb on the airplane," says Walter Korsgaard, a former bomb expert for the FAA and one of the first to arrive on the scene at Lockerbie and every other commercial airliner bombing in the last decade. "Go to the right airport, the right airline, and you can get it on. No question about that. The challenge is having the right combination of device, technology, aircraft, and placement."

Then too, though most terrorists today are well trained and highly motivated, they tend to know little about their targets. As TWA 847 approached Beirut Airport, which lies at the edge of the Mediterranean Sea, the tower denied permission to land. The terrorists demanded that the pilot land in the water. When the pilot carefully informed them that jets don't land in water, one hijacker raced back to the first class cabin, grabbed one of the emergency cards showing passengers evacuating a ditched jet, and shoved it in the pilots' faces, saying, "Yes they do—see?"

"If terrorists were smarter about airplanes and their environment," says Korsgaard, "we'd lose a lot more airplanes." Except for Pan Am 103, no one has even attempted to bomb a U.S. commercial aircraft or airport since 1986, according to statistics from the FAA's Office of Civil Aviation Security.

"There's only two ways of interpreting that," says Kosatka. "Either there are not threats, which I'm not sure I'd believe, or the system is working very well." The airline industry clearly prefers to take the latter view, and its officials



are quick to point out that holes have been deliberately exaggerated by a consulting industry that sells itself on the premise that current standards are not enough. "The so-called security experts are out to sell a product—themselves—and the best way to do that is to sell fear," says an airline industry official.

The FAA stays mum when it comes to discussing airline security, which in some ways is understandable. "Security reasons," says FAA spokesman Fred Farrar. He cites the highly sensitive Air Carrier Standard Security Program, which codifies between 50 and 100 measures, and adds, "We think the system is the best it's ever been. It meets the threat." Not even the critics, though, fault the FAA or the airlines for a security system they believe is more image than substance. "The FAA's in a real pickle," says McGuire. "Their charter says they have to regulate an industry that they also have to promote. They've got a contradictory mission." In addition, security is simply not the agency's primary mission. "The FAA was set up to move airplanes from point A to point B without running into each other," Koch points out.

Nonetheless, FAA security standards are often higher than those of foreign carriers, whose security is usually based on the comparatively weaker recommendations of the International Civil Aviation Organization, the U.N. affiliate that coordinates aviation standards for most nations around the world. ICAO standards continue to allow the boarding of unaccompanied bags—still the greatest threat—if they've been searched.

At a conference sponsored by the ICAO in Montreal last March, nearly 100 countries agreed "in principle" to mark all plastic explosives with one or more chemical additives, which will make plastic explosives easier to detect. This will help, but ICAO members include Syria and Libya, both of which have a reputation for state-sponsored terrorism. Talk about the fox guarding the hen house. Meanwhile, according to the Department of Transportation's Office of Intelligence and Security, the technology for foolproof bomb detection is still up to five years away.

Adnan Awad remains in hiding in the United States. For having told Western authorities about Abu Ibrahim and the intricacies of his bombs, he has a bounty on his head of perhaps $5 million (no one is sure of the precise figure anymore). "Terrorism is like a disease," Awad says, refilling his teacup, stirring, then laying the spoon near one of his pistols. "You need to do big operation right away, and no more disease," he says. "But here [in the United States] they wait and wait and wait."

You would think the chill that Awad's bomb gave security officials had demonstrated the need to anticipate trouble, rather than react to it. You would think that the unspeakable devastation of Lockerbie had at the very least become an instructive memory. But as you make your way through screening with barely a glance from the X-ray operators, you may do well to remember an observation made by the writer Eugen Kogon some 40 years ago. The atrocities of the past, Kogon said, lose their deterrent effect among the wild horrors of the present.

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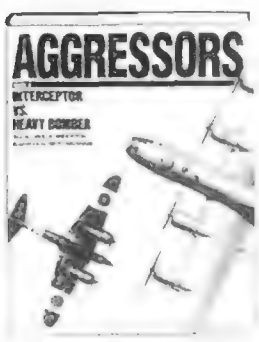

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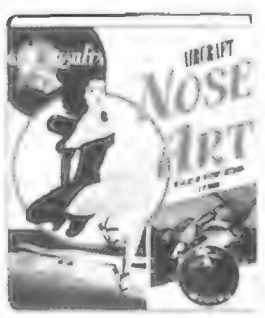

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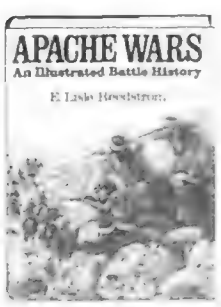

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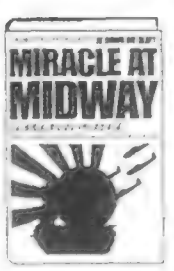

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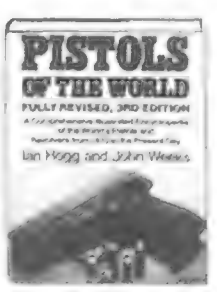

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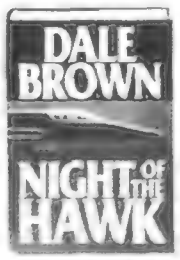

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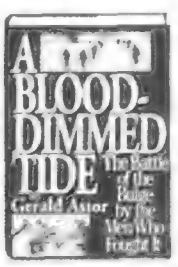

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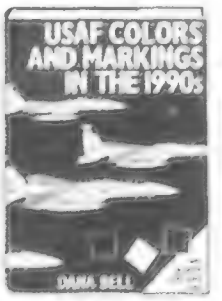

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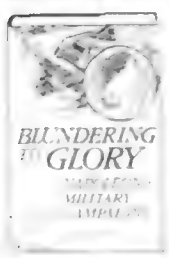

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I CAME, I SAW, I LOST

At Oshkosh, many are called but few are chosen.

by Stephan Wilkinson

Illustrations by Richard Thompson

In summer, musicians trek to Tanglewood, psychiatrists converge on Cape Cod, and social X-rays head for the Hamptons. People like me, however, who have built their own little airplanes, set course for a small Wisconsin city once best known for manufacturing fire trucks and overalls: Oshkosh.

There, amid an enormous T-square of concrete that for a week in August becomes the busiest airport in the world, we find adulation and occasional scorn, comradeship and infuriating crowds,

good advice and bad, friends to be made and fools to be suffered, and just about every rare airplane in the country that isn't ensconced in a museum. This is the Experimental Aircraft Association's annual fly-in—the world's biggest airshow, aviation flea market, and love-in for unusual aircraft.

Oshkosh is the one place we aircraft builders are adored, admired, understood, and safe among our own wacky kind. At Oshkosh I'm not subjected to questions from people like my wife's boss, who seems unshakable in his belief that I've built a model airplane. Or my neighbor, who smugly turns away when I admit that yes, strictly speaking, my airplane did begin life as "a kit," as though it were some kind of bolt-together Sears barbecue grill.

My airplane is a thoroughbred. It is an Italian design, a Falco, and has two seats, the strength and agility to fly aerobatics, and a purity of line that makes it faster than any factory-built machine of the same 180 horsepower. The credit goes to Stelio Frati, a shy, elderly Milanese with an equine face hidden behind thick, heavily tinted eyeglasses, who designed the Falco in 1955 and went on to create many other propeller-driven and jet trainers, utility and sport airplanes, and small transports. The Falco remains his favorite.

What I get credit for, however, is the decision to paint my little wooden Falco in a mock Italian Air Force color scheme of lurid red, industrial gray, and red-white-and-green rondels of the

And the Winner Is...

The homebuilder who trounced me—and 150-odd other aspirants for the Custom Built Kit Grand Champion award—was Myron Jenkins, a 70-year-old retired hardware manufacturing executive with a background in sheet metal work, welding, and shop skills. Jenkins arrived at Oshkosh with a nearly flawless 300-horsepower, 270-mph Glasair III fiberglass two-seater, his second homebuilt. He'd practiced for the Grand Championship by first building a smaller 160-hp Glasair I.

"That first Glasair, I didn't know anything about awards," Jenkins admits. "Brought it to Oshkosh, didn't even stay for the awards ceremony. A couple of weeks later, I got in the mail a bronze 'Lindy' for outstanding workmanship. It really surprised me.

"I started building this one just because I wanted another project, but by this time I realized what it took to make a Grand Champion. I don't have the patience anymore to do a perfect job, but I know what the judges are looking for. You need a sharp-looking paint job—something that stands out, makes the judges take notice—so I spent a lot of time on that. I put the trim stripes and lettering on first, then butted the white overall color right up to them, then sanded the edges down perfectly flush and put clearcoat over it so it was perfectly smooth. The judges thought that was great.

"Another thing that helps is prior exposure," Jenkins says. "I know one guy, he'd just finished a beautiful airplane in time to take it to Oshkosh, so nobody'd heard of him. I got the grand championship at a local fly-in here in Arizona, got grand champion at a regional meet in Texas, got best homebuilt at an antique fly-in, then went to the big Sun 'n' Fun fly-in in Florida and won both grand champion and great grand champion. So by the time I got to Oshkosh, everybody knew I was coming. They knew they had a winner there before they even started judging it."

To his credit, Jenkins is not compulsively touchy. "I know a fella, he never gets in his plane unless he takes his shoes off," Jenkins says with a laugh. "I maybe tell people to wipe their feet, but I'm not real fussy. They can put their hands on the paint if they want to, I don't care. I polish it up every once in a while anyway. It's a utility plane as far as I'm concerned. I'll fly it wherever I want to go, take anybody up who wants to ride."

Seven years ago, when he completed his first homebuilt, Jenkins was 63 and not yet a pilot. He earned his private license in his Glasair I. "Tell you the truth, the hardest thing for me, being older, was to learn to fly," he admits. "*Building* an airplane is a whole lot easier."

sort generally seen on pizza shops. It is the aviation equivalent of buying a Fiat and decorating it like Nigel Mansell's Ferrari, but I have no shame. (Well, almost none. My 83-year-old mother, bidding me adieu recently, shouted across an airport ramp crowded with passengers awaiting the local commuter, "It's darling, Stephan! It looks just like the models you made when you were 10!" I could have died.)

Since I last wrote about my airplane's journey by jitney-and-truck caravan from an upstate New York barn to a nearby airport ("Moving Day," October/November 1991), the Falco has matured into an entirely reliable traveling machine. It has taken me on business trips and pleasure journeys. It has been hosed by rain, hammered by turbulence, chased by summer thundershowers, and had its wings iced over. It has flown into major airports and grass strips, has landed both on its wheels and on its belly (the latter when a friend who borrowed the airplane neglected to put the landing gear all the way down), and has carried me to and through a variety of adventures.

At Oshkosh, the biggest adventure is simply landing, which is something like approaching a tipped-over beehive without getting stung. Airplanes wheel, dart, and bank onto short final while the tower gleefully stirs up a swarm of business jets, biplanes, World War II fighters, and Cessnas. "Silver and red Navion, keep it comin'," a controller radios. "Turn final now. Now, Navion." Suddenly I realize he's talking to my gray and red, vaguely Navion-shaped Falco. Apparently there are no paisanos in the tower who can tell the difference.

I'm in the middle of this madness because I've been rash enough to enter the Falco in the Best Homebuilt judging, competing with airplanes so finely crafted that the insides of their wings and bilges are more perfectly finished than the exterior of my entry. To be named a Custom Built Kit Grand Champion at Oshkosh is the homebuilder's equivalent of getting your bedroom on the cover of *Architectural Digest.*

My first mistake: I fail to thoroughly re-polish and detail the Falco before trotting, panting like a puppy, to the judges' shack to register it. Three judges with clipboards swarm over the airplane before I've even unloaded my bags. "If the engine's still warm, guy's just flown in, we'll ignore a few bugs on the leading edge," one judge confides. "But otherwise, the airplane has to be absolutely clean. Other than maybe dust from spectators walking past."

Swell. The Falco has harvested most of the gnats between Poughkeepsie and Oshkosh, there are fingerprints on the wings where passersby have fondled them, a thin film of crankcase-breather oil coats the belly, and the cockpit is a clutter of charts. At least I threw out the half-eaten Egg McMuffin.

I'm torn. If I hover anonymously in the background, none of the spectators will know that I am the Falco's proud builder. But if I make my ownership obvious, the crowd will inevitably produce at least one misguided soul who'll dog my footsteps, asking stupid questions and announcing that he too plans to build a Falco someday, but with a turboprop engine, perhaps, and maybe an open cockpit.

What the hell. It's a small price to pay for the opportunity to be envied, videotaped, and interviewed, so I find every excuse to mount the wingwalk and rearrange the seatbelts, refold a chart, wind the instrument panel clock, ponder the engine logbook, confirm that my oxygen bottle still holds the 2,000 psi it did 10 minutes ago.... "Hey, didja build this? Nice. I'm gonna buy the plans one of these days, but I'm gonna make mine out of fiberglass, not wood. Yeah, that's the ticket. My brother-in-law knows a guy who's got an old helicopter engine...."

Within hours I see that had I been serious about winning a prize at Oshkosh, I should have built three Falcos in or-

der to come up with a single flawless example. The average Grand Champion, judge Robert Herman tells me, is "the guy [who] has built three of every part." This is no exaggeration. Recently, two homebuilders pawed through the castoffs of a friend who was building a Grand Champion and were able to build two perfectly good airplanes from the leftovers.

I've never quite understood such compulsiveness, for it seems ultimately to result in airplanes that are sorely underused. The owners of such jewels hardly dare fly them for fear they'll get dinged, chipped, and dirtied. A carelessly dropped seat belt buckle can nick meticulously applied cockpit paint. A neophyte passenger can take a wrong step and scar a wing panel. A preoccupied lineman can scratch the finish with a fuel nozzle.

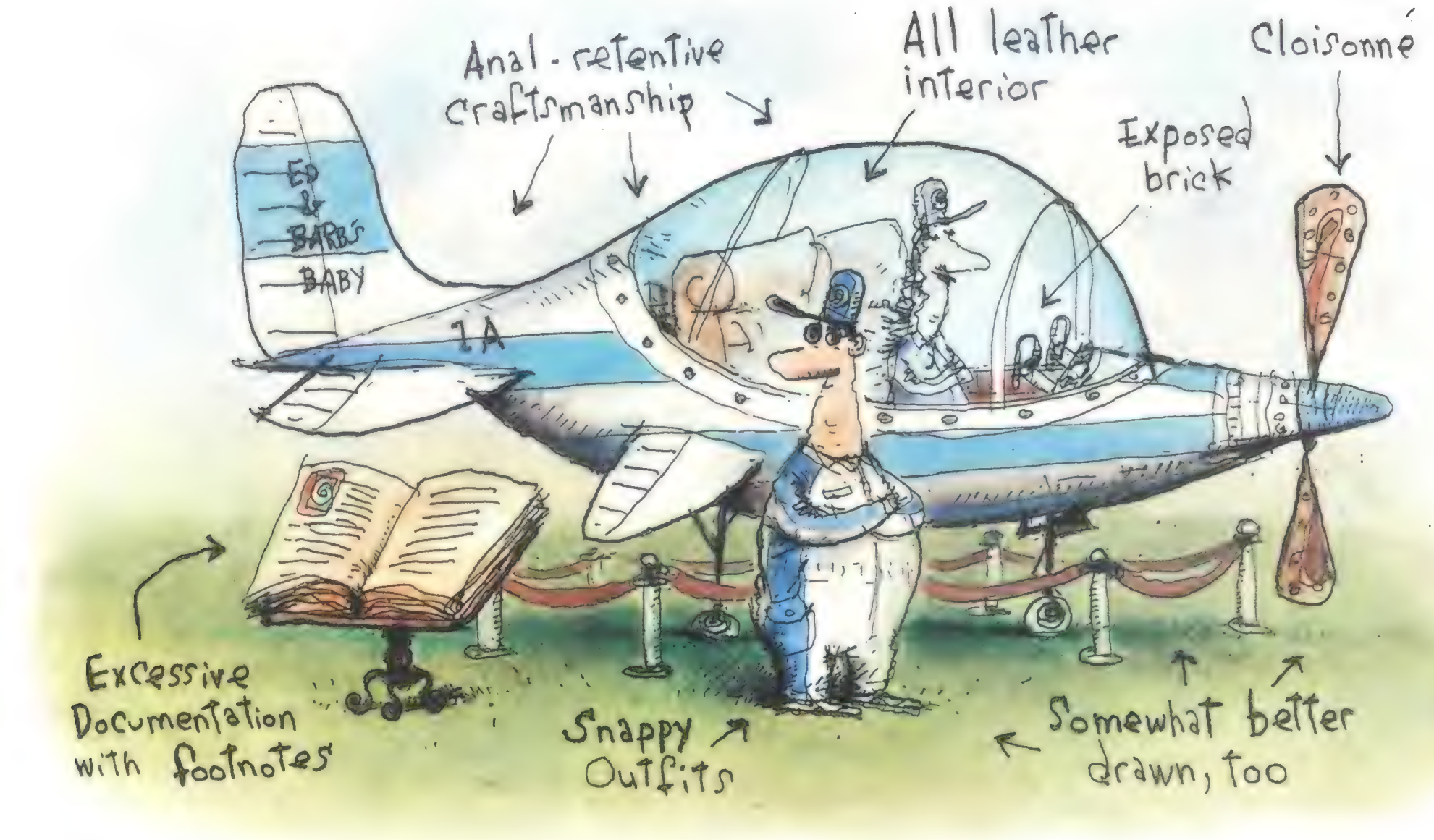
Like newlyweds with white wall-to-wall carpeting, the reality of muddy shoes in the cockpit is too much for such builders to bear. Their airplanes become showplanes and are flown from one exhibition to another, then put back in gilded cages. One frequently sees former "Oshkosh Grand Champions" for sale in aviation trade papers at inflated prices and with so few flying hours logged that it's obvious they haven't done much more than fly to Oshkosh and back home.

Peeking over one judge's shoulder, I see on his pad the "Scoring Decision Tree," a flow chart that leads to basic conclusions ranging from "deficiency is a safety item with potential catastrophic failure" (zero points) through "workmanship skills totally lacking, poor regard for aeronautical standards" (two points) and "could easily be improved with only slightly more work" (five) to the ultimate "flawless in all respects" (a perfect 10). I flatter myself by imagining a six—"minor flaws are easy to detect"—but realize I'm parked amid a squadron of nines and 10s.

"You'd be surprised how chickenshit we are when it gets down to the serious stuff," Bob Herman says. "Several years ago we had two airplanes in the Antique/Classic division with the exact same score. What decided the Grand Champion was that the slots on all the screws around the windshield and windows on one of them lined up."

Herman leads me to some nearby homebuilts to demonstrate the standards on which he insists (he obviously can't find them on mine). Absolutely parallel gaps on control surfaces. Paint jobs with no discernible ridges where masking tape has separated colors. Bellies as clean and smooth as the upper surface of the wing. ("A lot of builders will do a beautiful job up top, where everyone can see it, but I like to look under the wing and in the engine compartment," Herman confides.)

And, most important, keeping to a minimum the use of body putty to smooth inconsistencies before painting. "The most difficult thing to do fairly is determine how much bodywork somebody might have done before they painted," Herman says. "If a pilot brings a metal airplane and it's polished but unpainted, we can tell he didn't use any filler. But we're not seeing many metal airplanes anymore, because they're so labor-intensive.



"This airplane I'd B-sheet [eliminate from contention] just on a walkaround," Herman grumbles as we pass a handsome blue and white biplane. "He hasn't even bothered to clean the exhaust stain off the gear leg. And look at this," he says, pointing into the cockpit of a two seater so clean it looks like it should be wearing a "Sanitized for Your Protection" wrapper. "I don't like the way this builder has stuck that little bottle of windshield cleaner between the cockpit sidewall and a control cable. If he takes it out before he flies, I guess that's fine. But I don't like the fact that he's got it in there while the airplane is on display."

Builders who are seriously contending for the championship bring not only their airplanes but detailed logs and photo presentations of the construction process to help prove they have done the work themselves. (I've brought a snapshot taken by my 13-year-old daughter, but it seems to make little difference.) It's not uncommon—though strictly speaking, illegal—for wealthy sports to contract with professionals to assemble their kits. "That's not what we're looking for," warns judge Barry Basse. "Even some guy who puts $150,000 into the instrument panel but has an avionics shop build it, that's an automatic downer for me."

"You look at the photos and ask a builder how he'd built the ribs," says Herman. "If he starts bumbling around, you know the hardest work he did was signing the checks."

Some builders wear matching husband-and-wife jumpsuits in the colors of their airplane, with caps embroidered with its registration number—a move that should have no bearing on their airplane's score. "Theoretically it's not supposed to," Herman says. But, he admits, "If the builder is running around in a shirt he hasn't washed for three weeks—well, different things impress different people."

It's soon clear I'll never win a thing at Oshkosh, but the crowd loves the Falco for its classic shape and feisty paint job. I've placed a rude placard on the propeller warning spectators not to manhandle the airplane: "Kippa u hens off, doan wokkonna wings, doan opinnacowl," it begins. "U messwiddit, mei brekka u bonz." One friend, when asked whether she thought the sign amusing or tasteless, said, "Can't it be both?"

But the spectators buy into it, and soon people are dragging their friends over to read the placard, laboriously translating the pidgin Italian. And despite my ethnic incorrectness, the Falco soon becomes the Little Italy of the fly-in. Pilots, engineers, and enthusiasts from Roma and Modena, Torino, and Firenze gravitate to the airplane, clap me on the back, get their pictures taken shaking my hand, peek up the Falco's skirts and down its throat.

Some reminisce about their old friend Stelio Frati, a national hero in the Italian aviation community, and one tells me in broken English I am "man with golden hands." ("Yeah, and a golden pocketbook," grumbles a nearby homebuilder who seems to resent the money I've lavished on my toy.)

But then one of the Italians gently takes me by the arm and leads me to the Falco's military-legended vertical tail. "No 'i' in MILITARE," he says. "You have French—MILITAIRE."

I wonder: if my airplane had been otherwise perfect, would I have lost the Grand Championship because of a typo? What a fate for a writer.

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How do you take apart the world's largest flying boat? First find the people who had put it together.

The enigmatic Howard Hughes spent five years building his Flying Boat and one minute flying it. For the last 28 years of his life, Hughes kept the craft in storage.

by Preston Lerner

Photographs by Chad Slattery

Mark A. Smith is standing beneath a wing so colossal it seems to stretch into infinity. His hangdog expression suggests that he'd rather be somewhere else. It's Smith's unenviable job to seal the disassembled components of Howard Hughes' Flying Boat in heavy plastic so they can be shipped by barge from Long Beach, California, to the aircraft's new home near Portland, Oregon.

"The Guinness Book of World Records people are confirming that this is the biggest shrink-wrapping project ever," Smith says. From his tone, it's not clear whether he's amused or amazed. And that's perfectly appropriate.

Perhaps no aircraft has fueled a more potent amalgam of devotion and derision than this one, known as the Spruce Goose. Critics ridiculed it as the Flying Lumberyard, and history records that the wooden seaplane's only flight—with Hughes at the controls—didn't last even a single minute. Still, since 1982 millions of visitors have paid homage at this gargantuan shrine to the genius, persistence, and, ultimately, folly of Howard Hughes. "It had its own religion about it," says Hughes enthusiast Dave Drimmer. "Just about everybody who walked into that dome and saw it had the same reaction: *Oh my God!*"

But shrines, no matter how beloved or awesome, are seldom profitable. Last spring, the airplane's lessee, the Walt Disney Company, announced that it wouldn't renew its lease. Unable to find another lessee, the Aero Club of Southern California was forced to put the airplane up for sale. In July, after considering a half-dozen serious bids, the Flying Boat was sold to Evergreen International Aviation for an undisclosed sum to serve as the centerpiece of the future Evergreen AirVenture Museum in McMinnville, Oregon.

Then the tricky part began.

After the airplane was sold to an aviation museum in Oregon, its new owners were faced with the daunting task of moving the eight-engine behemoth to its new home.

To prepare for the move, the aircraft and exhibit accoutrement were stripped of their parts—and in some cases, their dignity.

Stan Soderberg maintained the Flying Boat for 45 years. He likened his intimate relationship with the airplane to "a good marriage."

The most obvious—and glorious—way to move the airplane would have been to crank up its eight 3,000-horsepower engines, rock the 219-foot-long ship out of the whitecaps off Long Beach, and grind up the Pacific coast to McMinnville at 175 mph. Unfortunately, the task of getting the airplane airworthy after 45 years in storage would have been nearly as monumental as the job of building it.

Transporting the leviathan over public roadways was out of the question. This left the folks at Evergreen with only one option: they had to break down the largest airplane in the world into the largest airplane components in the world. It wasn't going to be easy.

"The Flying Boat wasn't built to be disassembled," says George Kruska, the Evergreen honcho in charge of the $1.5 million disassembly. Engineering drawings were missing. The tooling had been destroyed. Bolts were frozen. Wood joints—particularly those secured with glue—were studies in frustration. "Many, many people told me, 'You'll never do it.' Or 'You won't do it in six months,' " Kruska says. "I said we'd do it in six weeks."

This was more than just a job to Kruska. Half a century ago he'd helped *build* the airplane. So did the other men Kruska hired to refresh his memory: John Boseker, who'd performed the stress analysis on the wooden structures, Bill Leas, who'd designed the cradle that supported the airplane and the hangar that housed it, Stan Soderberg, who'd maintained the airplane from completion to disassembly, and mechanic Van Storm, who'd been on board during the sole flight.

For these men, the decision to preserve the airplane was especially poignant. "I'm happy it wasn't just sawed up," Leas says. In front of him, ironically, the Flying Boat is in pieces—thousands of them—but each one, down to the tiniest spacer and the greasiest bolt, has been catalogued and photographed for reassembly in McMinnville. "It's quite a work of art, and it belongs in a museum," Leas says softly. "A lot of nice people worked very hard on it, and I'm glad to see it wasn't all for naught."

The idea for the sea monster was hatched in 1942, when Allied ships were being sunk by German U-boats faster than they could be built. Industrialist Henry J. Kaiser, the man behind the mass-produced Liberty ships, wanted to create a fleet of seaplanes large enough to carry tanks. And while he didn't know anything about aviation, he knew somebody who did: mercurial Texas millionaire Howard Hughes.

Then 36, Hughes was a movie mogul and a notorious ladies' man, but he was best known as a daredevil flier. He'd set a speed record in 1935 with his graceful H-1 racer. The next year he broke the transcontinental record, then he broke his own record in 1937 and set a new around-the-world mark in 1938. He also owned a controlling interest in TWA and had worked with legendary designer Kelly Johnson on the Lockheed Constellation (see Moments & Milestones, June/July 1989).

In 1942, the government contracted with Hughes and Kaiser to build three HK-1 seaplanes. At the time aluminum was in short supply and Hughes opted to build the prototype of wood. To achieve structural rigidity, he employed a process called Duramold, in which alternate layers of wood veneers and epoxy resin glues were

The massive airplane, built mostly of birch, weighed 200 tons when fully loaded and could carry 14,000 gallons of fuel and 750 troops. Its wingspan was longer than a football field; its tail was eight stories tall. Eight engines contained 448 spark plugs and delivered 24,000 horsepower. The flight engineer's engine instrument panel alone contained 64 gauges.

Removal of the fabric-covered rudder, which was 48 feet tall and weighed 1,400 pounds, provided a warm-up for the challenge offered by the huge wings.

The Flying Boat's interior exemplifies how Hughes' demand for perfection resulted in an aircraft that was artfully engineered, exquisitely crafted, and, as a result, years behind schedule.

When Hughes died in 1976, his holding company wanted to permanently disassemble the Flying Boat and distribute its parts among nine museums. A flurry of protests kept it intact.

sandwiched and heat-treated. (Most of the wood was birch, so besides being a name Hughes hated, "Spruce Goose" was also a misnomer.)

The project was big to begin with, and, like Topsy, it just growed. "We started off with a twin-hull airplane," Boseker recalls, "but that turned out not to make much sense, so we went to a single hull. There was a six-engine design and there was a seven-engine design, and finally there was an eight-engine design. We started off with about 250,000 pounds, and by the time we got finished, we settled on 400,000. It could be configured to carry a 60-ton tank, or two 30-ton tanks, or a 30 with a wheeled vehicle." Or 750 soldiers. Or a combination of the above.

Until you see the airplane, it's difficult to grasp its magnitude. Each propeller weighs 800 pounds. The top of the vertical stabilizer towers eight stories above the keel. The

wings are large enough for a person to stand inside. At 320 feet, the wingspan is longer than a football field. To put these numbers in some sort of perspective, the Flying Boat is 20 percent larger than a Boeing 747.

Considering the size of the project and the technological innovations involved, progress was predictably slow. Hughes' demand for perfection verged on obsessive, but his attention often flitted to other projects. Kaiser pulled out of the program before the war ended. In 1944, as the U-boat menace diminished, the government tried to cancel the contract. Hughes agreed to finish the prototype with his own money—$7 million, as it turned out, in addition to the $18 million the government had spent.

It wasn't until late 1947, after the Senate had begun investigating whether Hughes had illegally profited from his wartime contracts, that the airplane was finally ready to debut. On November 2 it was towed out into Long Beach harbor for taxi tests with reporters as passengers. The first two runs were uneventful. But after dropping off most of the newsmen, Hughes ordered hydraulics

John Boseker (left), an engineering consultant, performed the original stress analysis on the wooden structures nearly 50 years ago.

As manager of the disassembly, George Kruska, who helped build the airplane and now works for the Flying Boat's new owners, completed the job in just six weeks.

Systems mechanic Van Storm was on board for the airplane's sole flight. He was one of five Flying Boat veterans who served as consultants and managers for the disassembling.

One of the project's most tedious exercises was fitting and taping acres of shrink wrap to the dismantled parts (left and above).

foreman Tom Dugdale to unlock the flaps, then told hydraulics engineer Dave Grant, flying as copilot, to set them at 15 degrees—takeoff setting. At about 80 mph, the Flying Boat lived up to its name, covering one mile at an altitude of 70 feet. Afterward, a high-spirited Hughes told the media why he had made his surprise flight: "It felt so good I just pulled it off."

The Flying Boat never flew again. Exactly why remains one of the numerous mysteries surrounding Hughes. Initially, at least, he seemed determined to complete the flight test program. He made structural modifications to the tail, replaced the pneumatic throttle controls with rheostats and electric servos, installed new radios and engine components, and modified the instrument panel. In 1948 he housed the airplane in a climate-controlled hangar on Long Beach harbor, where Stan Soderberg faithfully maintained it. "It never entered my mind that this was the end of the project," Boseker says. But Hughes eventually lost interest, and the Flying Boat—along with the small cadre of men who worked on it—languished in obscurity. As Leas puts it, "You did your job, and time passed."

After Hughes died in 1976, a complicated

series of transactions put the airplane into the hands of the Aero Club. Then, in 1982, the Flying Boat was moved from storage to a new home in an aluminum dome alongside the *Queen Mary*.

Walking into the dome and beholding such an impossibly large airplane may have been well worth the $17.50 admission for many, but the Flying Boat was no more successful as a tourist attraction than it had been as a seaplane. Even Disney, which assumed the lease in 1988, couldn't make

The world's largest flying boat, reduced to the world's largest flying boat pieces, returned to Long Beach harbor for its final journey.

any money with it—or the *Queen Mary*—despite the company's marketing expertise. And when no one showed any inclination to take over where Disney left off, the Aero Club announced it was offering the airplane for sale.

Would-be buyers came out of the woodwork. One developer wanted to use the airplane as the centerpiece for a mini-mall. But the clear winner was Evergreen owner Delford Smith. He had land, money, restoration experience, and a collection of historic aircraft. When his museum opens it will feature about 30 airplanes, including a German Bf 109, a DC-3, a Stinson tri-motor, and an SR-71 (on permanent loan). "We were looking for a home for our child," says William Schoneberger, the Aero Club board member who headed the search. "And [Smith] said, in effect, 'We are going to display this piece of aviation history in an appropriate manner, with dignity.' "

But first they had to get it up to McMinnville. Altogether, about 75 people helped disassemble the airplane, though rarely more than 25 at a time. The propellers came off first, then the engines, the floats (which had been filled with beachballs to ensure buoyancy), the wingtips, and so on, until the Flying Boat was no longer an airplane but a collection of parts. At first there was something melancholy about the process. But later, as components were bathed in the shafts of light streaming through the open top of the dome, the airplane seemed to grow in stature.

Exquisite craftsmanship abounded—in the graceful curves of the hull, in the complex cross-bracing of the tail, in the wooden spars so finely finished they looked metallic. "The workmanship was really good—really good," aircraft mechanic Ralph Fiebeck says with wonder. "I don't know where the hell you'd find people to do work like this today."

Last October, less than two months after disassembly began, the airplane was shipped out of Long Beach. Smaller components were trucked overland, while the hull, wings, and tail went by barge up the Pacific coast, up the Columbia River, and southwest on the Willamette River. By the end of the year, everything had arrived in McMinnville, where reassembly is scheduled to be completed by 1995. The Guinness people never awarded the project a shrink-wrap record. But that's all right. The Flying Boat has already made all the history it needs.

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THE CASE OF THE MISSING MATTER

There's more to the universe than meets the eye—much more.

by M. Mitchell Waldrop

"I remember being startled even that first night," says veteran astronomer Vera Rubin. On November 14, 1977, she and colleague Kent Ford were down at the big Mayall telescope at Kitt Peak National Observatory in Arizona, testing a brand-new technique to study the motions of stars within spiral galaxies. And Rubin, who has the air of a feisty, energetic grandmother (which she is), couldn't wait to see how things were turning out. So every now and again she left Ford at the helm of the telescope and took a freshly exposed photographic plate downstairs to the observatory's darkroom, where she developed it on the spot.

What each plate recorded (they hoped) was the spectrum of each galaxy, from the brightest point in its center to the faintest edges of its spiral arms. This was something no one had ever done before. But if Rubin and Ford could do it, with the aid of a new image intensifier Ford had developed, they could use some basic physics to calculate the velocity of the stars in each region. Parts of the galaxy whose emissions were "redshifted" toward longer wavelengths would be moving away from us, whereas regions whose emissions were blueshifted toward shorter wavelengths would be moving toward us. When the telescope's spectrograph was properly aligned, the resulting spectrum of the target galaxy would be essentially a graph, a plot showing how the velocity of stars varied from one side of the galaxy to the other.

And that's exactly what Rubin saw in plate after plate as she held them up to the darkroom light. "I remember this incredible delight," she says. "We'd done it!"

Yet even in the midst of her excitement, Rubin remembers being taken aback. Without thinking much about it, she had always assumed that the velocity recorded in these graphs would decrease as it was measured farther and farther from the galaxy's center. A spiral galaxy is shaped like a fried egg, with most of the stars concentrated in a bright central bulge. The stars out in the spiral arms presumably orbit around this massive center in the same way that planets orbit the sun. In accordance with Newton's law of gravity, the distant planets always orbit more slowly than the inner planets; likewise, the outer stars in any given galaxy ought to move more slowly than the inner ones.

Except that they didn't. For galaxy after galaxy, Rubin's freshly developed plates showed that the velocity curves flattened out. The outer stars were moving just as rapidly as the inner stars.

In the rush of completing the night's observations, Rubin admits, "I wasn't wise enough to just look at the plates in the

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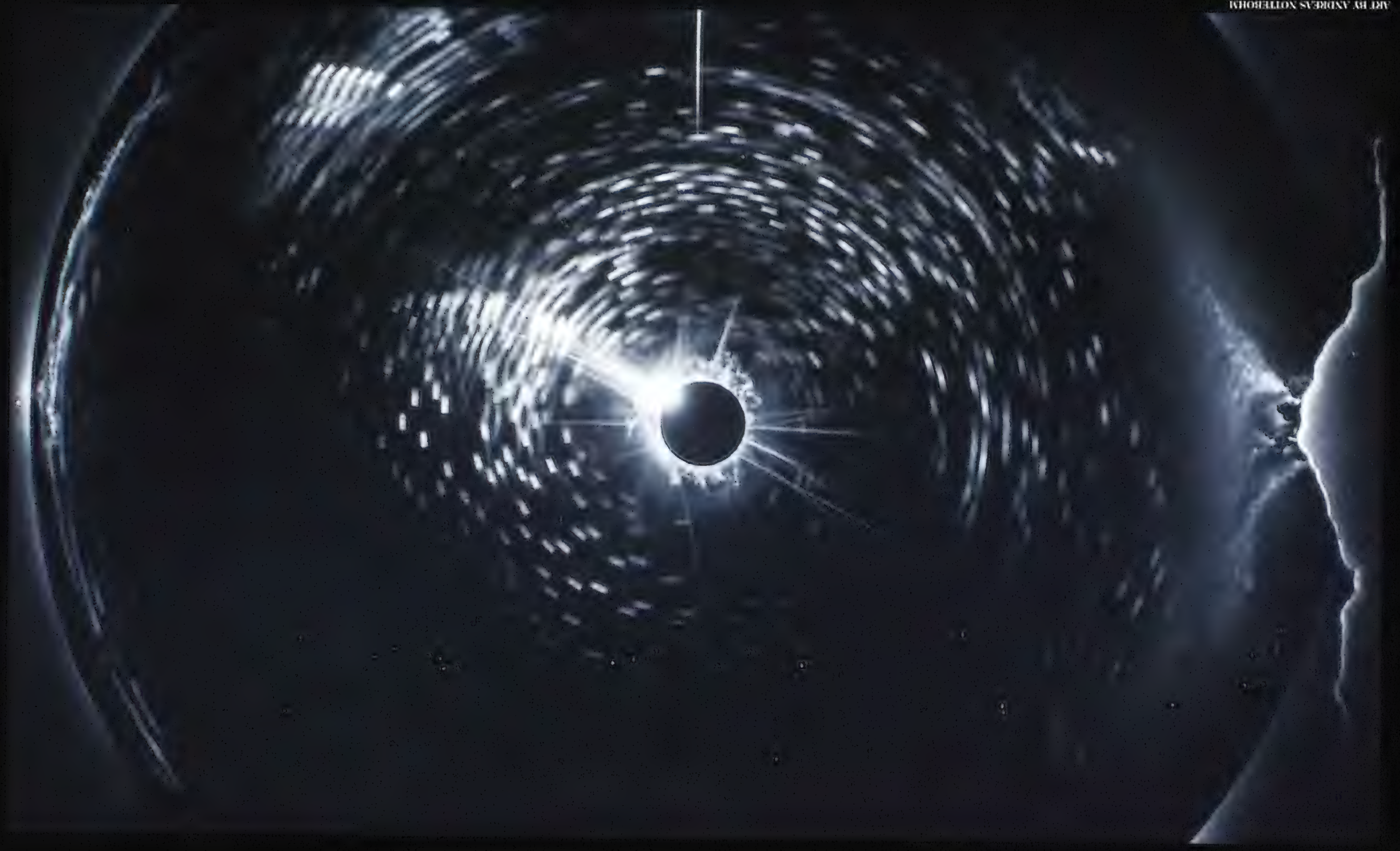


CHRISTOPHER SPRINGMANN

darkroom and realize immediately what was going on." It wasn't until she and Ford were going over their results several days later that the full implications of those flat velocity curves hit home: the total mass in each galaxy—the stuff that holds visible stars in orbit through gravity—is *not* concentrated in that bright central bulge. In defiance of all photographic evidence, which shows that the number of visible stars in a spiral galaxy always falls off rapidly beyond a certain distance from the center, the total mass of the galaxy continues to increase for some distance at an undiminished rate. Somehow, Rubin and Ford realized, there is an immense amount of mass out there that isn't in the form of stars, or anything else they could see. Somehow, each spiral galaxy was surrounded by a kind of nimbus, a ghostly halo of "dark matter."

"By the time we'd done 10 of these curves, we said, 'We've just got to publish,' " says Rubin. Their paper, released in 1978, attracted the attention of astronomers everywhere. Invisible matter? There had been occasional hints of unexplained gravitational forces before, as far back as the 1930s. But the idea had always seemed remote—until now.

"Observationally, it was very, very satisfying," says Rubin. "Anybody could look at these curves and see what they said." Subsequent observations by Rubin, Ford, and many other astronomers only strengthened the conclusion: in every spiral galaxy they looked at, the stars were orbiting too fast. Furthermore, in every cluster of galaxies they looked at, the individual galaxies were moving too fast. In neither case could the visible stars exert enough gravitational force to hold things together. To make up the difference, the dark matter had to outweigh the visible stars by at least a hundred times—and perhaps a great deal more than that.

By 1980 the idea of dark matter had completely overtaken the astronomical community. And in the decade since then, the implications have become even more staggering. It's now abundantly clear that galaxies are not the mighty dreadnoughts of the cosmos they appear to be. They are more like flecks of foam upon an immense dark sea, going wherever the underlying currents take them. Indeed, the ebb and flow of dark matter is almost certainly what created galaxies in the first place. The huge gravitational field of dark matter may even determine the fate of the universe itself, deciding whether it expands forever or ultimately collapses. And if this dark cosmic ectoplasm is really made of something that transcends matter as we know it—as many scientists now suspect—then it may well point the way toward a new understanding of the most basic laws of physics.

So. What *is* this stuff?

"I really thought we'd know more by now," sighs Rubin, who has worked at the Carnegie Institution's Department of Terrestrial Magnetism for the last 27 years. "In 1980 I really thought that in ten years we'd have it. It's a big disappointment to realize that the answer is as far away as ever."

Indeed it is. For more than a decade now, astronomers and physicists have gone in search of dark matter with every telescope and every detector that seems halfway suited to the task. And for more than a decade now, they've been stymied. How are they supposed to detect something that's completely invisible when they aren't even sure what it's made of?

With subtlety, creativity, and a nearly inhuman capacity for patience, apparently. Since conventional detection techniques have fallen short, a number of projects has recently sprung up around the world to attack the problem head-on by devising ultrasensitive techniques that are especially tailored to dark matter detection. Nowhere is that effort pursued more doggedly than at the Center for Particle Astrophysics, a consortium of far-flung physicists and astronomers headquartered at the University of California at Berkeley.

"The search for dark matter is one of the most heroic experiments we can attempt," declares center director Bernard Sadoulet, the deceptively soft-spoken French-born physicist who took the lead in organizing the center in 1989 and obtaining funding from the National Science Foundation. More precisely, he says, the search for dark matter comprises many

experiments, each keyed to a different guess as to what it is.

"First," says Sadoulet, "you have to decide whether the dark matter is baryonic or not. By baryonic, I mean the ordinary stuff made of protons, neutrons, and electrons." In fact, astronomers have good reason to think that some of the dark matter *has* to be ordinary baryonic stuff, even if we can't see it. By measuring certain rare isotopes such as deuterium, helium-3, and lithium-7, which were produced by thermonuclear reactions among the protons and neutrons that came out of the Big Bang, astronomers can estimate the total density of the protons and neutrons in the universe today, which is the same thing as the total density of baryonic matter, whether dark or shining. And the measurement of these rare isotopes suggests that baryonic matter accounts for roughly a hundred times the mass in visible stars.

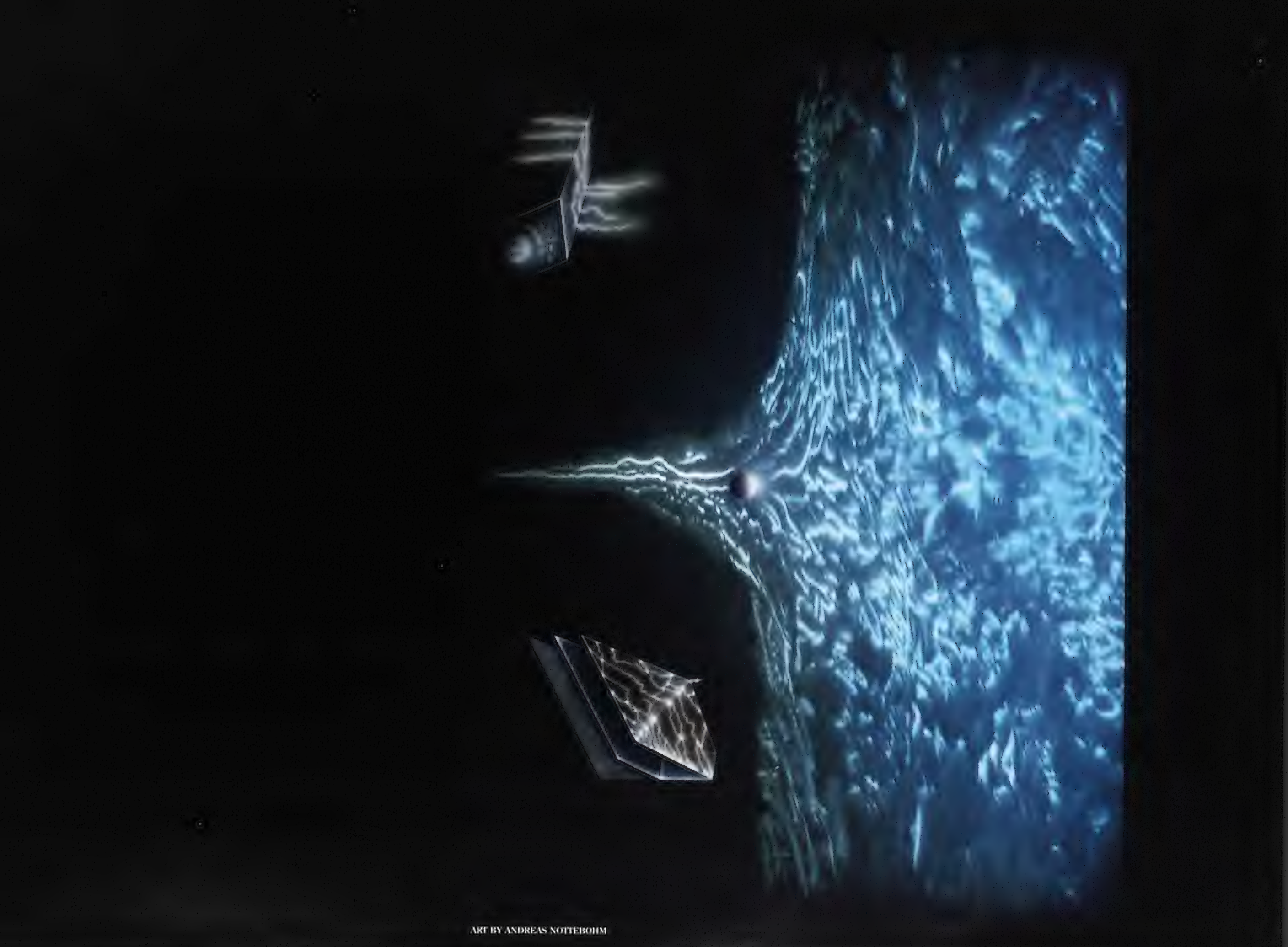
In 1977 Vera Rubin (below) observed that the outer stars of spiral galaxies are orbiting nearly as fast as the inner stars. This startling discovery set off the now-fervent search for dark matter, undertaken by such scientists as Bernard Sadoulet (opposite).

RICHARD NOWITZ

Now a hundred times the mass of visible stars is an intriguing number, since that's about the minimum mass Rubin and others have measured for dark matter in the largest clusters of galaxies. But where is it? And why is it invisible? Sadoulet notes that some of it may be in the form of very diffuse hydrogen and helium gas drifting through intergalactic space, but probably not all of it. If there were that much gas out there, it would either block out the light of distant galaxies or emit a steady stream of X-rays, neither of which seems to be happening.

There is only one other solution for baryonic dark matter, says Sadoulet: a population of Massive Compact Halo Objects, or MACHOs. "The idea," says Sadoulet, "is that for reasons that aren't understood, the gas has condensed into very small brown dwarf stars that aren't massive enough to burn." MACHOs might also include a number of real stars that have long since burned out, or even an occasional black hole. But whatever they are, MACHOs would be no larger than the planet Jupiter, making them far too small to see over interstellar distances. It would be like standing in Los Angeles and trying to make out a mosquito in New York. Because their mass would be concentrated in a relatively small volume, MACHOs would leave most of space empty. So starlight from distant galaxies would shine through unimpeded, and these hypothetical swarms of brown dwarfs would be essentially invisible.

But not, fortunately,



ART BY ANDREAS NOTTEBOHM

undetectable. In the mid-1980s, Princeton University astronomer Bohdan Paczinski pointed out that if a MACHO passed in front of a distant star, its gravity would ever so slightly bend and focus the light, causing the star to look a tiny bit brighter for a few hours. Might it be possible to observe that fleeting brightening? The Berkeley center has recently launched an effort to do so.

"Our idea is to look at the Large Magellanic Cloud," says Saul Perlmutter of the Lawrence Berkeley Laboratory, who is one of a dozen scientists working on the project. The Large Magellanic Cloud is a smallish irregular galaxy that orbits our own Milky Way about 160,000 light-years out, which presumably means that we are looking at it through swarms of MACHOs orbiting in the Milky Way's halo. Eventually, one of these MACHOs is going to pass in front of a Magellanic star, causing it to brighten. The trick, of course, will be to notice the one star that twinkles in the midst of 10 to 15 million others, then sort out any real MACHO event from a wide variety of pulsating stars, eclipsing binary stars, and flare stars, which also vary in brightness. "So even if we see one," says Perlmutter, "we're going to have to follow that star for a long time to show that there's nothing unusual about it."

He and his colleagues will be working at Mount Stromlo Observatory near Canberra, Australia, using a 50-inch telescope. They should be able to detect MACHOs even if they make up only 10 percent of the mass in our galaxy's halo. So if they see nothing, that will be very significant: it will mean that most of the halo is made of *non*baryonic dark matter-something that isn't matter as we know it.

This is a possibility that Sadoulet and his colleagues at the Berkeley center are taking very seriously, whatever the outcome of the MACHO search. Indeed, there are good reasons to think that most of the dark matter in the universe *has* to be nonbaryonic. Isotope measurements may tell us that baryonic matter is roughly a hundred times more abundant than what we see in stars. But those same measurements also tell us that baryonic matter can't be any more abundant than that. In the mid-1980s, as astronomers looked at the relative motions of galaxies on a scale of hundreds of millions of light-years, they began to find evidence that dark matter outweighs the matter in visible stars by as much as a thousand times. The rest has to be...something else.

The evidence for such a conclusion is still ambiguous. But many cosmologists are inclined to believe it, if only because that figure would bring the overall density of dark matter tantalizingly close to what they call the "critical density"—the boundary between cosmic immortality and ultimate cosmic death. Numerically, critical density works out to be absurdly small, equivalent to the mass of only a few hydrogen atoms per cubic yard. But if the true average density of the universe is greater than this critical value, then Einstein's general theory of relativity tells us that the collective gravitational field of all the mass in the universe will eventually bring the cosmic expansion to a halt, whereupon the universe will begin to contract, collapsing faster and faster until it ends with a Big Bang in reverse—a Big Crunch. Conversely, if the true average density is equal to or less than critical, then the universe will expand forever. Gravity simply won't be strong enough to stop it.

The huge gravitational field of dark matter may even determine the fate of the universe itself.

Unfortunately, Einstein's theory by itself doesn't tell us the average density of our universe. But even leaving aside the recent data on large-scale galaxy motions, cosmologists have two good reasons for thinking that the true density is very close to the critical value.

The first is the cosmic paradox of galaxy formation, a problem that has become increasingly acute in the past decade as astronomers have mapped out the distribution of galaxies and clusters of galaxies on scales of hundreds of millions of light-years. The presumption is that these immense structures began to form in the aftermath of the Big Bang some 16 billion years ago as gravity took hold of random fluctuations in

WIMP Watch

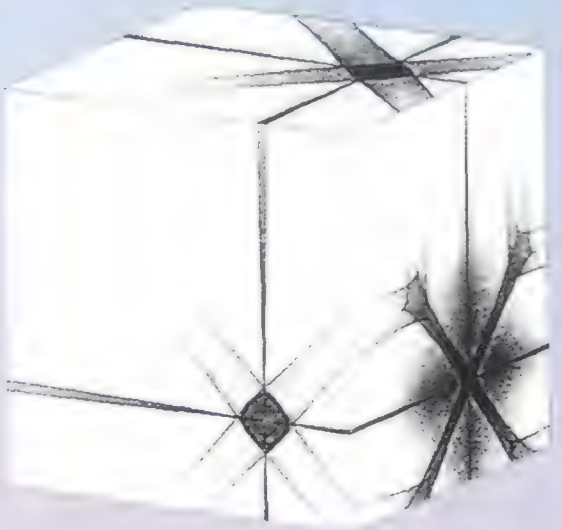
How do you trap a WIMP—a Weakly Interacting Massive Particle—when no container in the world could possibly hold it? You can't. But the next best thing is to find evidence that a WIMP has momentarily visited your container. That's what Bernard Sadoulet and other scientists at the Center for Particle Astrophysics in Berkeley, California, are trying to do.

If several billion WIMPs are passing through our bodies and everything else around us every second, all you have to do is take a block of some suitable material—the detector—and watch it very closely to see if one of its atoms suddenly recoils. If the impact appears to come out of nowhere, the likely culprit is a WIMP.

In practice, of course, this observation is anything but easy. There are two major challenges. First, these hypothetical WIMP particles almost never interact with ordinary atoms. For a typical laboratory-size detector (Sadoulet is using a two-pound chunk of material), you can expect roughly one WIMP interaction every 10 days. Over that same period, unfortunately, you can also expect a barrage of similar-looking recoil events caused by cosmic rays streaming down from every direction in the sky. To have any hope of detecting that one rare WIMP interaction in the midst of all the noise, you have to put your detector deep underground in a tunnel, out of the reach of cosmic rays. Next, to block out the tiny bit of naturally occurring radioactivity emanating from the tunnel itself, you must surround the detector with thick lead shielding. Then you have to choose your materials very, very carefully to minimize any residual radioactivity in the shielding itself—not to mention the pumps, electronics, and even the material of the detector, all of which can build up a measurable amount of radioactivity just from being exposed to cosmic rays on the surface of Earth.

The second challenge: this rare WIMP interaction affects only one atom in the detector out of several trillion trillion similar atoms, all of which are vibrating incessantly from heat energy. To have any hope of detecting that one crucial WIMP event, you have to cool the apparatus down as close as possible to absolute zero, where all atomic motion stops. And then you have to find some way of detecting the one-atom recoil by looking at the block as a whole, since there's no way to monitor every atom individually.

Sadoulet and his colleagues have devised a plan of attack that starts with a pilot project just to test the detector technology. The project's Stanford contingent, headed by physicist Blas Cabrera, has already constructed a suitable tunnel. Measuring a slightly claustrophobic 12 feet wide by 12 feet tall, the tunnel lies about 35 feet below Stanford's west campus.



In this computer simulation of a WIMP striking a cube of crystal silicon, the dark pattern represents the vibrational energy of a ballistic phonon wavefront, which arrives at the surface about one microsecond after impact.

The fist-sized detector will sit at the end of the tunnel amid a tangle of refrigeration equipment and electronics racks, looking like a leaden six-foot Rubik's Cube inside its layers of shielding and insulation. The refrigerator itself, built by Oxford Instruments and now undergoing checkout in Berkeley, is capable of maintaining the detector at a temperature of .045 degrees above absolute zero, which is -459 degrees Fahrenheit.

The first detector to go into the tunnel will probably be the one designed by the Berkeley team working under Sadoulet. Their basic approach is to start with a block of crystalline germanium—a semiconductor that can be manufactured with extreme purity—and fit it with ultrasensitive temperature sensors to look for the almost infinitesimal heat pulse generated by a WIMP impact. At the same time, they plan to apply a small voltage to the crystal to collect any electrons knocked loose by the event. Too many electrons would be a sure sign that the event wasn't caused by a WIMP, which should cause little disruption. A more likely culprit would be a stray neutron or gamma ray that somehow made it through the shielding. "It's extremely important to measure as many parameters as you can to make sure the event isn't faking," says Sadoulet.

After the Berkeley detector has had a fair shakedown period, it will likely be replaced by an even more ambitious device being developed by Cabrera and his team at Stanford. Their idea is to "listen" for the sound of a WIMP impact, a mini shock wave known as a "ballistic phonon wavefront." To accomplish this feat, the Stanford group will start with a block of silicon (another element that can be made with extreme purity, thanks to the semiconductor industry). Then they'll use chip manufacturing techniques to cover its surface with a fine network of solid-state motion sensors made of tungsten. These sensors should be able to pick up the infinitesimal pattern of vibrations as the sound wave strikes the crystal's surface, and it is this resulting pattern that will enable the Stanford physicists to deduce exactly where the impact occurred inside the crystal. The location of the impact, in turn, should help them reject false events with even more assurance: a WIMP impact will occur at only one point, whereas a neutron or gamma ray will leave a trail of interactions.

DRAWING BY BLAS CABRERA, STANFORD UNIVERSITY

the cosmic fireball and caused denser regions to clump together more tightly. Mapping the universe now should tell us a lot about conditions then.

But therein lies the paradox. The universe today turns out to be very clumpy indeed. Astronomers' maps show galaxies congregating into clusters and superclusters on a vast scale, leaving equally vast empty spaces in between. From a cosmic perspective, the universe looks almost like a mass of soap bubbles, with galaxies mostly confined to the bubble walls. And yet the universe in its early days was not clumpy at all. Quite the opposite: according to a faint whisper of microwave energy known as cosmic background radiation—the "afterglow" of the Big Bang—the infant universe was remarkably smooth and homogeneous. The most recent and striking evidence comes from NASA's Cosmic Background Explorer satellite. In April 1992, after painstaking analysis of their first year of data, COBE scientists announced that the biggest variations they could find in the radiation following the Big Bang amounted to no more than 0.0006 percent—six parts per million (see "Ancient Whisper," April/May 1992).

So there seems to be no way around it: the amount of matter in visible stars simply couldn't have exerted enough gravitational force to produce the huge cosmic structures seen today, even over the course of 16 billion years. According to the best computer simulations, the only way such tiny density fluctuations could have grown so fast is if there was lots of dark matter around to help—enough to bring the universe very close to critical density. If that's the case, then it's no wonder visible galaxies are still surrounded by dark halos. The halos must have formed first, invisibly clumped up by the force of their own immense gravity, while the ordinary matter that later formed into visible stars trailed along like an afterthought.

The second reason for thinking that the density of the universe is near the critical value comes from a compelling theory developed in 1980 by Alan Guth, a physicist at the Massachusetts Institute of Technology. Guth showed that in the first infinitesimal fraction of a second after the Big Bang, as the infant universe was exploding outward at an unthinkable rate, subtle quantum effects could have triggered a period of even more rapid expansion that he dubbed "inflation." And the effect of that cosmic inflation, he realized, would have been to make all of the matter in the universe extremely smooth and homogeneous—just as the data from the COBE satellite has now shown it to be—while forcing the matter's density to be almost precisely equal to critical.

CHRISTOPHER CORMACK

Blas Cabrera believes the mystery of dark matter may be solved by detecting an unknown particle.

Coming on the heels of Rubin and Ford's evidence for dark matter in galaxies, Guth's arguments went a long way toward convincing any remaining doubters. If his inflation theory is correct, then the implications for dark matter are astounding. The mass in all visible stars, averaged over the vast spaces between them, amounts to no more than 0.1 percent of critical density. Even if you include all other baryonic matter, such as intergalactic gas and MACHOs, you still come up with only three to 10 percent of critical density. So all the rest, at least 90 percent of all the mass in the universe, has to be something else. And once again, the question is: What?

As it happens, particle physicists have been quick with an answer. The Big Bang was the ultimate particle accelerator, they point out. The temperatures and densities during that event were ferocious enough to have produced *any*thing. Every kind of elementary particle, known and unknown, would have come pouring out in unimaginable abundance. Most of them would have decayed very quickly, of course, leaving just stable particles: the protons, neutrons, and electrons that make up ordinary matter, as well as the photons of background radiation. But suppose, just suppose, that some of the exotic particles were stable as well. They would still be around today, 16 billion years later. Now suppose that each of these exotic particles also possessed a small mass. Their collective gravitational influence on visible stars and galaxies would be

ART BY ANDREAS NOTTEBOHM

enormous. And finally, suppose that these particles were electrically neutral and interacted very, very weakly with ordinary baryonic matter and photons. They would be utterly invisible. They would loop through the galaxy with nothing to slow them down. Every second they would come streaming by the billions through the sun, through Earth, even through our bodies—and we would never notice. In short, they would behave exactly like dark matter.

Of course, there is no known elementary particle that fits this description. Not to worry: in concocting their various unified field theories, physicists have hypothesized ghostly "axions," "photinos" endowed with supersymmetry, and many other exotic entities, any one of which would do nicely.

> **"The search for dark matter is one of the most heroic experiments we can attempt."**

"There are so many possibilities," sighs Sadoulet, who has already devoted nearly a decade to this effort. In some ways, he says, the most appealing of these possibilities is a family of three neutral, weakly interacting particles known collectively as neutrinos. Neutrinos are produced by nuclear reactions in the sun and by certain forms of radioactivity here on Earth. And they were certainly produced by the zillions in the Big Bang, which means that they must still be flying around today as a kind of shadow of the microwave background radiation. In fact, the only thing neutrinos seem to lack as a dark matter candidate is mass: in conventional particle theories neutrinos are usually thought to have no mass whatsoever. But we don't *know* that that's the case, says Sadoulet. If one of the three forms of neutrino has even a tiny mass—roughly 0.0000001 percent the mass of a hydrogen atom would do the trick—then it would exert exactly the kind of invisible gravitational forces that Rubin and company have observed. This possibility has already inspired a number of experiments to detect that tiny neutrino mass. The work is under way at particle accelerators and nuclear reactors around the world and scientists expect to have an answer—perhaps within a few years.

But even if these experiments are a smashing success, scientists don't believe that massive neutrinos are the whole story. It turns out that neutrinos emerging from the Big Bang fireball would have been what cosmologists call "hot": they would have been moving at velocities approaching the speed of light. Theorists such as Berkeley's Marc Davis have shown through computer simulations that these hot neutrinos would have been moving much too rapidly to condense into clumps on the scale of galaxies, which are about 100,000 light-years across. In fact, the smallest hot-neutrino clumps would have been at least 10 to 100 times larger than that—the size of whole clusters of galaxies. So Davis estimates that massive neutrinos can account for no more than about 30 percent of critical density. The rest, some 70 percent of the mass of the universe, must be "cold" dark matter: particles that orbit the galaxy slowly. Of course, in cosmology "slow" is a relative term. In this case, it means no more than a few hundred miles per second, or roughly 20 times faster than an orbiting spacecraft. Many scientists have done calculations and computer simulations showing that such particles of cold dark matter could account for the formation of galaxy-sized clumps quite nicely. These hypothetical particles have even acquired a name: Weakly Interacting Massive Particles, or WIMPs. The trick is to detect them—without knowing which of the WIMPs, if any, is actually real (see "WIMP Watch," p. 64).

The frustrating—yet fascinating—thing about the search for dark matter is that there always seems to be yet another possibility. Has there ever been a more elusive cosmic entity? Sadoulet, Cabrera, and their colleagues know full well that they may search for years and see nothing. Axions, magnetic monopoles, tiny black holes, "shadow matter"—for all these scientists know, dark matter is made of a particle that they won't ever be able to detect. The only thing they can do is keep looking, without the satisfaction of knowing if they are even close.

The Cost of Success

Norman R. Augustine, Chairman and Chief Executive Officer, Martin Marietta Corporation

Throughout our lifetimes, there are events that remain fixed in our memories like freeze-frames on a television screen, forever reminding us of exactly where we were and what we were doing at the time we learned of them. Such an event was Neil Armstrong's historic first step on the moon, a moment that made us proud to be not just Americans but Earthlings.

Another such event was that horrible instant in which the space shuttle *Challenger* exploded. As we grieved over the loss of seven human lives, we were forced to realize that no matter how routine spaceflight might come to appear, it is still a very risky undertaking.

"In the space business, 99 percent perfection is the equivalent of disaster," Wernher von Braun once remarked. As we continue to move beyond the bounds of this planet, we must continue to insist upon perfection, to settle for nothing less. This I cannot emphasize too strongly.

We should not be so preoccupied with avoiding failure that we lose interest in trying to succeed.

But at the same time, we should not be so preoccupied with avoiding failure that we lose interest in trying to succeed. Especially at times of challenge, we must guard against becoming more focused on what can go wrong than on what can go right—more concerned with investigation than invention.

It is in humanity's nature to wonder what lies beyond the familiar, to take that step beyond what we know into what we don't know: in short, to take a risk. The history of humanity is studded with risk-takers, individuals who strode beyond their fears to conquer the unknown. From those early tribes that wandered across the land bridge from Asia to North America and eventually populated a second continent, to that first bold sailor who left behind the reassuring sight of land and ventured out to sea, humans have progressed only by taking risks.

The willingness to accept those risks has not always led to immediate success. But failure can sow the seeds of later success. The ability to learn from failure, as well as build on success, has been the hallmark of the American space program.

The United States' first attempt to launch a satellite, for example, ended in failure. In fact, by the end of 1959, two-thirds of the nation's 37 satellite launch attempts had failed. In the 1960s, 10 of the first 11 rockets launched to gather data on lunar landing sites were failures. Three astronauts died in a fire aboard an Apollo capsule before it even left the ground.

Yet despite all the failures leading up to that dramatic first landing on the moon, the Apollo program of the 1960s had strong public support, in part because the American people realized that our national prestige and technological superiority were at stake. The Soviet Union had launched the first artificial satellite and the first human into orbit. In that cold war era, it was vital that America match—and surpass—these achievements.

As President John Kennedy observed at the time, we choose to explore space not because it is easy, but because it is hard. It is still hard today, but otherwise the situation is quite different. There is no longer a cold war competition to help justify the American space program. Rather, we now need to convince the public that space exploration is warranted purely on its own merits.

And what are those merits?

Consider some of the practical benefits we enjoy today as a result of the space programs of the past. The benefits of satellite systems alone go on and on: military warning, search and rescue, nuclear monitoring, environmental research and monitoring, instantaneous communication via satellite with virtually any spot on the globe, satellite-based navigation systems that can pinpoint our location within a few feet, weather satellites that enable us to track storm systems literally minute by minute.

Outside the realm of satellites, scientific breakthroughs stemming from the space

Risk taking is an indispensable part of space exploration—and of human nature.

program have been made in such disparate areas as microelectronics, medicine, and advanced materials, to name just a few. Indeed, when we want to emphasize how up to date a technology is, we often describe it as "Space Age." Likewise, an intellectually demanding pursuit becomes "rocket science."

As to what space-related benefits lie in the future, we can only speculate. Could we have giant solar collectors orbiting Earth, beaming down enough electricity to power the world? Laboratories, indeed complete factories, taking advantage of the vacuum and microgravity of space to conduct experiments and manufacturing operations that are impossible on Earth? Wrist telephones? Personal navigation systems? Perhaps even the capability of intercepting meteors that threaten to strike Earth? The list of possibilities is virtually endless. Undoubtedly, there will be whole areas of science, whole new technologies, that we cannot even imagine today.

But we cannot achieve such goals merely by sitting back and waiting for success to occur. Rather, we need to pursue risk. And not just the risk of human lives, although that is always a factor, but the risk of resources, both intellectual and financial.

In 1990, I had the honor of serving as chairman of the Advisory Committee on the Future of the U.S. Space Program. One of the issues my colleagues and I addressed is of special concern today: affordability.

Space exploration is not a shoestring venture. During the Apollo years, space program spending reached a peak in 1967 of approximately 0.8 percent of the gross national product, 4.5 percent of the federal budget, and about 6 percent of total federal discretionary spending. After Apollo, the NASA budget declined by each of these measures, and for the past 15 years the investment has hovered at about 0.2 percent of the GNP, 1 percent of the federal budget, and 2.5 percent of total federal discretionary funding. Last year, this amounted to about 15 cents a day per American.

The advisory committee recommended a steady 10 percent annual growth in the NASA budget into the next century, peaking at about $30 billion in 1990 dollars by the turn of the century. Further, we noted that a sustained level of about 0.4 percent of the GNP will be necessary if the United States is to provide its citizens with the benefits of a vigorous space program.

If the administration and Congress cannot support the space program at that level, then the United States will have to scale back its programs, including delaying achievement of goals in our manned space program. Continuing to strive for ambitious goals without the means to fund them fully is the worst of all choices.

For the same reason, the advisory committee believes that the program for the human exploration of Mars should also be tailored to the funds available rather than to some relatively arbitrary date for accomplishment. The reason is two-fold: first, we cannot accurately predict the costs or the rate of development of the revolutionary technologies that will be required, and second, we must hold paramount the safety of the astronauts who will risk their lives in such a pioneering venture.

It is impossible to guarantee an error-free program in space—indeed, such a guarantee is impossible even for much more mundane pursuits here on Earth. Despite such risks, humanity will continue to reach outward: first to Mars, then perhaps to the asteroid belt, and on to the outer planets. And in so doing, we will carry out the journey into the unknown—the journey that was started so many millennia ago by those wandering tribes who first reached the American continent and by that unknown sailor who first turned his back on the land to see what lay beyond the horizon.

Today, the universe itself is our horizon. It is also our destiny.

Continuing to strive for ambitious goals without the means to fund them fully is the worst of all choices.

Can Russia's Space Program Survive?

The people who made spaceflight routine fight bankruptcy and chaos with characteristic tenacity.

by Tom Harpole

Photographs by Irina Mikhailovna Kuznetsova

Some 30 years after Nikita Khrushchev's shoe-pounding avowal to bury capitalism, Guy Severin, ex-test pilot and former Soviet aerospace industrialist, guides a tour through the museum in what was once his top-secret factory. Hundreds of devices from Soviet aerospace programs are on display, and Severin hints there are more he still can't reveal. He badly needs to sell anything he can. His role as salesman is wearisome, he says.

Severin has spent most of his adult life at the helm of the Zvesda (Star) factory, one of the secret engines of the former Soviet aerospace system. He extols the salient features of his ejection seats, his manned maneuvering unit and extravehicular activity suits for spacewalks, and his zero-G suits developed for long-duration orbital flight. "Basically, we made life preservation equipment, but everything, including my role here, was top secret," he shrugs. He moves on to a simple gray appliance that, despite its aerodynamic design, doesn't seem to belong in this collection. It is, in fact, his latest life preservation device. He hopes it will help save the factory.

"The MR 500 slices, it dices, it will cut 500 kilograms per hour of any vegetable you wish into any geometric shape you need," Severin recites, seemingly unaware of the ironic cross-cultural echo in his sales pitch. It's chilly in the museum, two stories beneath his factory in Tomilino, southeast of Moscow, and it's long after quitting time on a Friday. Severin's inexperience as a capitalist shows. Without prompting, he offers to sweeten the commercial slicer deal. "For one thousand dollars, we'll pack it and ship it." He has 999 more at that price.

Throughout his even-toned pitch, he later admits, he was calculating how many of his engineers he could continue to pay by selling one slicer. He admits to more than that. He admits he's desperate.

Russia's economy is declining, he says, then he reconsiders the word "de-

SOVFOTO

The old iconography gives way to the new: while paint peels from a statue of Lenin near the Moscow Aviation Institute, Soyuz TM-11, emblazoned with "SONY," rockets to Mir with a Japanese guest.

cline." A slide implies a predictable leveling. "Abyss," he decides, better describes Russia's economic future.

The potholed road to Tomilino passes dozens of weedy lots where unfinished concrete apartment blocks topped by rusting construction cranes stand abandoned. At one time, the village of Tomilino flourished because of the steady flow of aerospace contracts that Soviet

ministries awarded to the Zvesda factory. During the cold war boom of the '60s and '70s, Severin paid for and oversaw the construction of apartment blocks for workers, as well as schools, theaters, gymnasiums, stadiums, and summer camps. Today the tacit belief that the factory will always support the village is as illusory as the wealth behind Tomilino's development. But workers and their dependents cling to an unspecific hope that their lives will "normalize."

"Their hopes are absurd," Severin says, shaking his head. "There was never anything normal about our space program. Once a project was approved by the government there would be more money pouring in than you could eat. Now we wonder about our next meal."

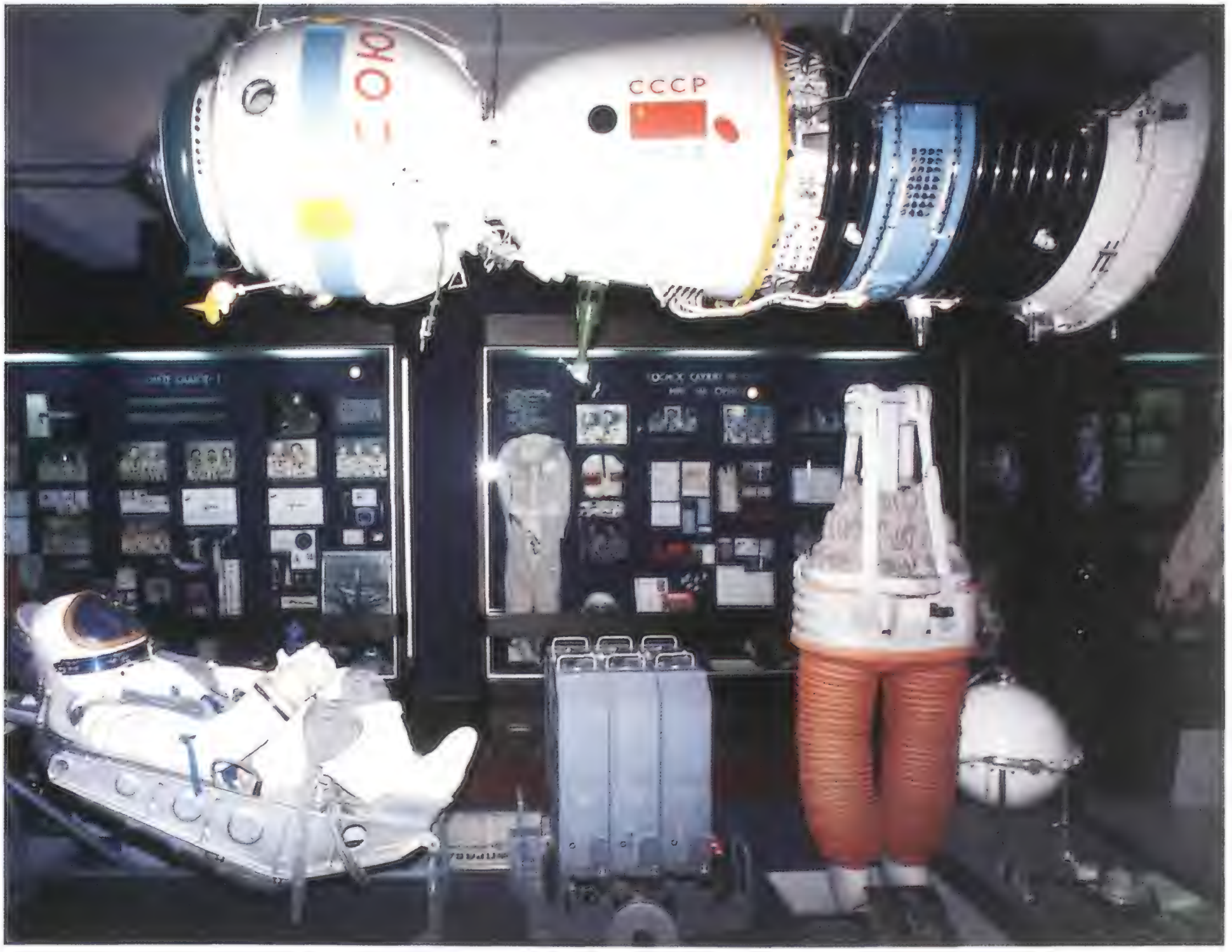
Since 1991 Severin has been trying to sustain a payroll of 3,000 employees by converting his factory from the manufacture of aerospace equipment to the production of consumer goods. He is enterprising, and his inventiveness led to the development of a machine to fight the Colorado potato beetle, which he claims the CIA introduced into the Soviet Union. The pest is ravaging the 1992 potato crop in collective farms and *dacha* gardens all over Russia, but no one can afford the equipment that fights the bug—or that peels, slices, or dices what remains of the crop.

For most of the last 30 years, the Soviet space program dominated the world, brandishing its ideology in thousands of streaking ascents. The Communists made it look easy. By 1991 Soviet cosmonauts had spent a total of 23 years in space. U.S. astronauts have spent eight. In 1990, despite social upheavals threatening to rip their country apart, the Soviets launched successful missions an average of every five days—a rate three times higher than that of any other nation. Since 1987, Mir, a third-generation space station, has been almost continuously inhabited, its crews exchanged flawlessly and at any interval officials desired. Yet now, with the experimentally democratic Russian federation barely a year old, what Communists considered their most visible symbol of triumph over capitalism is all but grounded.

It is not yet clear how much of the Soviet achievement in space the Russians will be able to preserve. I visited Moscow almost a year after the disintegration of the union to ask scientists, engineers, and officials who had devoted their careers to the space program whether they thought they could continue. I found most of them languishing in poverty and wondering what would happen next. The mood among these unemployed was like that of artists who have just learned of the death of a rich, cruel patron. They know that big science is only possible when supported by big government, but not one, from the most jaded *apparatchik* to the most idealistic cosmonaut, wanted to stop the tailspin of totalitarianism, not even to avoid the ugly new reality of costs-versus-benefits that had stalled their careers.

Vasily Mishin (above) has survived his differences with Party bosses and, at 75, is still designing rockets.

Guy Severin's factory can produce vegetable peelers as well as spacesuits, but so far nobody's buying.



A model of the Soyuz spacecraft dominates the display of life support equipment at the Zvesda factory museum.

If any person can salvage the glory from the old system, leaving behind its corruption and excess, it's Yuri Koptev. Koptev is Boris Yeltsin's choice to head the new Russian Space Agency, an organization still jockeying for position as overseer of the civilian space program. Koptev was second in command at the Ministry of General Machine Building, a once-powerful bureaucracy that oversaw production of nearly all Soviet spacecraft and launch vehicles. Yeltsin liquidated the ministry in February 1992, but the RSA has not emerged as its replacement. There is a great deal of disagreement among Russians about which organizations have authority over what areas of the space program.

Koptev's rumpled polyester suit, strong handshake, and riveting eye contact distinguish him from some of his well-dressed subordinates, obviously former Party elites, who came from the ministry with him. He is a bear of a man who occupies a corner office that could accommodate a volleyball game. As the first general director of the Russian equivalent of NASA, he is learning that competing for launch customers is doubly difficult for the disenfranchised Russians, even though they are the undisputed leaders in launch capability. Koptev could go a long way toward supporting the thousands of institutes and factories that depend on the space program if only he could sell launch services in the world market. He seems to have made a priority of overcoming the obstacles to doing so.

"America, China, and France do all the international trade in space," Koptev explains. "The French control 60 percent of the commercial launches. We face a cartel that is understandably reluctant to see us enter the market. This cartel protects companies in the launch business with export laws and licensing restrictions." One law that Koptev is referring to is the U.S. Department of State's International Traffic in Arms Regulations (ITAR), a document, issued in the 1950s, that defines a satellite as an implement of war. This law dictates that a U.S.-manufactured or -licensed satellite cannot be launched on a Russian vehicle. Koptev lights a brittle Russian cigarette, apologizes for smoking, and continues. "It's too convenient to let needless cold war habits prevent the Russians from entering the market," he complains. "The struggle between communism and capitalism has been replaced by a new ideology of protecting profits of Western companies that supplied the cold war."

The Agreement on Cooperation in Space, one of many Presidents Bush and Yeltsin signed last June, decreed

an exception to ITAR by enabling the United States to issue an export license for the launch of an INMARSAT 3 satellite. (Five months later, the INMARSAT organization made history by becoming the first Western company to buy a launch on a Russian rocket. The Russian federation's DB Salyut, manufacturer of the Proton rocket, will get $36 million for the 1995 launch.) The language of the agreement leaves no doubt that the deal is unique and goes on to say that both governments "support the application of market principles to international competition in the provision of launch services, including the avoidance of unfair trade practices." This clause implies a Catch-22 for the Russians, who are unable to declare a real value on aerospace hardware developed under the Soviet system, in which the concept of accounting was as foreign as net profits. If they must wait to be told by their launch business competitors what they may charge, they lose control of their market.

Proud of past achievements, RSA director Yuri Koptev (above) hopes to bring Russian launch expertise to the world market.

Scientist and cosmonaut Konstantin Feoktistov (opposite, top) grumbles about the state of space science and education in Russia.

The negotiated exception that paved the way for the INMARSAT contract was part of the agenda at the June 1992 summit between Bush and Yeltsin. Koptev knows that he cannot depend on summit conferences to underwrite a space program. He also knows that changing the U.S. regulations governing satellite exports will require literally an act of Congress. Perhaps that's why, when asked about American proponents of cooperation in space, he can so readily name Senator Barbara Mikulski of Maryland. "She's a person with an exact vision of the importance of a worldwide effort to build a future in space," he says. When asked who his supporters are in the Russian parliament, he struggles and finally remembers a couple of surnames: "Androv and Hizha," he says, "and of course Yeltsin himself."

Russians realize that it's not just trade protectionism but lingering cold war angst keeping them out of the space club. "Forgetting the connection between preeminence in space and military superiority takes time," says Igor Shumilov, a diminutive rocket designer and Chairman of Cosmic Flight at the Bauman Institute. The institute is a top technical university that has graduated many cosmonauts over the years. In his Moscow flat, Shumilov hefts a Hungarian-made 16-gauge shotgun and muses on the pressure the military exerted on rocket scientists even before Sputnik. "This gun has a double safety," he says, fumbling with it as he tries to make his fingers remember its lock. The gun is an exquisitely crafted piece of metalwork. "The great irony is that gunsmiths take justifiable pride in a tool with such tragic possibilities," says the rocket engineer. He dry-fires it at a mirror and adds quietly, "Attitudes change slowly."

The change will require more than the establishment of separate agencies for military and civilian space activities, although that was a step in the right direction. Mikhail Gorbachev created Glavkosmos eight years ago, for the first time taking the sole operational responsibility for the space program away from the Soviet military and trying to shift activity in space toward the goal of financial return on investment.

Glavkosmos, once a part of the Ministry of General Machine Building, survives in Russia as a small private marketing organization. Still led by the Gorbachev-appointed I.A. Dunayev, Glavkosmos has had no involvement in several recent deals with the West and is currently under U.S. trade sanctions for negotiating the sale of cryogenic rocket engine technology to the Indian space program.

Most Russian corporations are selling their expertise directly, without intermediary or protocol. Last October the RSA ratified a $1 million NASA contract for studies to be conducted by NPO Energiya, the aerospace firm that designed the Buran shuttle and Energiya rocket. But the agency is not automatically consulted in international deals. Several other state agencies were involved in cooperative agreements between Deutsche Aerospace and various Russian partners, including a joint venture with Guy Severin's Zvesda to develop a new spacesuit.

General Pyotr Klimuk, the commander of the manned space training facility at Star City, has flown orbital missions twice and endured an aborted mission during which he experienced 20 Gs and landed in the Altay mountains near China. Stranded in waist-deep snow, he and crewmate Vitaly Sevsatyenov simply built a fire and waited.

Now Klimuk seems mired again, but up to the challenge. He takes personal responsibility for sustaining morale at Star City. Rather than giving an interview, he delivers an impassioned, optimistic speech. Striking his desk with his thick hands for emphasis, he insists the future holds promise. He projects an aura of unapologetic honesty. "Yes, the Buran is on ice," he says. "We're economizing every way possible, that's why all the lights are out in the hallways." He adds: "Watch your step out there."

Klimuk's monologue is often interrupted by one of the dozen rotary phones on a credenza. He's occasionally forced to shout into the antiquated Russian phone system. The day before I visited, French cosmonaut Michel Tognini was successfully put aboard Mir. Klimuk hangs up from his latest interruption, obviously pleased. His palms catch the light from the tall windows to his left as he announces, "We have signed contracts to train and take four more French cosmonauts to the Mir space station."

Were it not for the French contracts—at $12 million a ride—there would be no point in opening the gate at Star City. Even though Yuri Koptev says that only military space spending has been cut back and funding for the civilian space program has remained stable, runaway inflation makes it difficult to fix any real value on the space budget. The fact is the Russians can no longer afford to launch their own manned rockets.

In early November an independent commission reported that more than a thousand space research centers had received only 50 percent of that year's allocations. Yet the Russian parliament, in its repeated attempts to cope with inflation running to 2,000 percent per year, periodically ordered pay raises for each of the six levels of wage earners from the former Soviet system of pay scales. Every raise ordered costs jobs. Hundreds of laboratories, institutes, factories, and suppliers have simply closed their doors. No wonder Guy Severin, when appraising the current state of Russian aerospace programs, often just says "chaos."

Cosmonaut Gennady Strekalov wants to focus work in space on protecting Earth's fragile environment so that his daughters will inherit a clean, safe planet.

In this state of emergency, Russian officials, scientists, and cosmonauts unanimously acknowledge that their only hope to continue manned space exploration is to work cooperatively with other countries. A legacy of redoubtable accomplishments in space sustains Russian pride. The explorers know the value of what they have to give to, as well as gain from, international partners. The ruin of the Soviet system hasn't diminished their dreams or taken away the heart to continue a quest against long odds.

Vasily Mishin is one old Russian dreamer who has never been quiet or servile. The chief rocket scientist of the Soviet space program from 1966 to 1974, he has designed as many successful rockets as anyone alive. "Internationalizing space science implies more than continued employment for Russian scientists and engineers," says Mishin. "It is the only logical way for our world to pursue the cosmos. Space exploration will never be done properly in the service of politicians or stockholders."

Mishin never deviated from his ethical standards; throughout his brilliant career he made many enemies in the Soviet system. In 1967 he refused to approve the launch of Soyuz 1 but was overruled for political reasons. The mis-

Pointing out his father's grave in a photograph, Igor Shumilov of the Bauman Institute speaks emotionally of those who fell defending Stalingrad in World War II.

sion caused the first spaceflight fatality, killing Vladimir Komarov.

Mishin contributed to the R-7 series and the Soyuz and Proton launch systems. He still claims his greatest design was the N1-L3 rocket, the big one that was supposed to propel Soviets to the moon. It failed on the launch pad three times and made it to the second stage once. Meanwhile, a dozen Americans walked on the moon, grabbing the political currency of lunar conquest. Consequently, Mishin became the first great scapegoat of the Soviet space program. In 1974 he endured what he calls "moral exile"; he was stripped of all design responsibility and banished to the Moscow Aviation Institute.

He regards his exile as an honor, considering its source, as does a cadre of colleagues with whom he is currently working. Despite having suffered a heart attack, at age 75 Mishin is animated and passionate. He hungers for a challenge. He and his associates are designing a "return rocket," a truly reusable launch vehicle they hope will put Russian rocket science back in the vanguard. "The world needs a $10 million delivery system," Mishin says. "We are close to a practical design." He won't elaborate because his new design has to be patented internationally, a process with which he is unacquainted.

Mishin blames today's impossibly expensive commercial and manned launches on corrupt *apparatchiks* and subsidized scientific indolence. "Thousands of obedient engineers and scientists wasted entire careers working under a Soviet system in which chest-puffing politicians set priorities for space," he says. He also wonders if American taxpayers realize they are missing the greatest bargains in the history of space exploration by not taking advantage of Russian technology now for sale. "Tell the Americans that it is foolish to reproduce our efforts," he says. "Don't waste money and time doing it all over again."

Igor Shumilov of the Bauman Institute expresses similar ideas. He likes to think cooperative ventures in space could thrive as an amalgam of cultural differences. "For example," he says, "America's computing power is said to be ten years ahead of Russia's and the gap is widening. But intuitive ability can be quashed by computers."

The Boeing Commercial Airplane Group has recently verified Shumilov's wisdom by planning a technical research center near Moscow. Ben Cosgrove, a Boeing senior vice president, recently told *Aviation Week & Space Technolo-*

gy that because Russia has lagged behind the U.S. in development of supercomputers, it was forced to develop "more elegant" mathematics and computer algorithms that reach solutions with far less number crunching power. The algorithms could save Boeing time and money, Cosgrove said.

"Space science evolved under extremely different conditions in our countries, but both countries had enormous achievements," says Shumilov. "Cooperation by scientists around the world could result in unimaginable progress." Shumilov worries, however, that the next generation in Russia will not have as much to contribute. In the clamor of history's biggest bankruptcy, space science is becoming a forgotten discipline. Shumilov laments the loss of the brightest science students to commerce. "Rocket science doesn't pay well in Russia," he says. He looks down at his finely grease-seamed palms and explains that he spent the morning at a Moscow train station trying to repair his car.

The most pernicious threat to the Russian space program seems to be the lack of inspiration and enticements for a next generation of scientists. Behind the walls of the Moscow Aviation Institute, the major training center for aerospace science since 1945, one of the last statues of Lenin left standing in Russia erodes; its white paint curls and flakes and litters its pedestal. Oleg Alifanov, dean of the School of Astronautics, cites his bitter disappointment in the recent abrupt abdication of his brightest Ph.D. candidate, a man who had a thesis prepared but suddenly quit to start a business. Alifanov is an avuncular man with the gentle voice and manner that comes naturally to some big men. He concedes that he understands why the most imaginative people in Russia are trying to survive the economic catastrophe by assimilating capitalist habits. "Personally, I think the quality of those Russians who want a career in science is unlikely to improve for some time," he confides. "We seem to be getting the mediocre, the unmotivated, the conservative who can't dream."

Alifanov's mentor at the institute, the energetic Vasily Mishin, says bluntly, "My generation of scientists must shoulder the load of continuing space science until this chaos is resolved in Russia." He holds out little hope for gestating brilliance in the current ranks of the Moscow Aviation Institute, where he still lectures.

One bitter, articulate voice complaining about the loss of talent in Russian space science belongs to Konstantin Feoktistov, who in 1964 became the first scientist to orbit Earth. "My flight was a reward for the excellence of my science," he sniffs. Feoktistov was instrumental in constructing the Vostok rockets and was chief designer of the Salyut space stations. His fingerprints are all over the Mir space station design as well. He lays blame for the devastation of the Russian space program not on the current economic upheaval but squarely on the transgressions of the Communist Party. Feoktistov, who retired three years ago, believes the whole country is suffering from a crippling psychological dilemma of vast proportions. "I knew many decent, if not very intelligent people who, in order to make careers as administrators and managers, had to join the Party," he says. "They had ethical questions that they had to smother. Doing so broke something in them; they were all sick of spirit and sick of themselves. So we had decision-makers who were all of low intelligence and abnormal in other ways. Our biggest priority should be to raise and educate honest, good-hearted people. The Soviet system destroyed those kind of people."

Irina Solovyova, who lives in the Star City high-rise built for the first cosmonauts of the 1960s, understands how ideologies wreck spacefaring aspirations. She was to be the world's first woman cosmonaut. It is said that Valentina Tereshkova was chosen instead of Solovyova in a last-minute decision. Tereshkova's parents were factory workers. In the 1960s the Socialist system looked askance at Solovyova's parents—they were teachers. Yet Solovyova doesn't have the sour outlook of Feoktistov.

In her capacity as a psychologist at Star City, Solovyova doesn't see any overt signs of hopelessness among the cosmonauts-in-waiting. She makes this observation over a lunch of fried cabbage and amid the

Psychologist Irina Solovyova and her daughter (above) must compensate for the meagerness of a cosmonaut's salary by growing some of their own food.

As a dean at the Moscow Aviation Institute, Oleg Alifanov has witnessed the decline in the caliber of student the institute attracts.

gripes of her grown children, who haven't eaten meat in weeks. "Prices have increased 100 times, our salaries have increased five times, so we eat simply now. Cosmonauts earn less pay than NASA janitors," she says with resigned grace. "Everyone here is growing a garden and we will be fine through the winter. Man is adaptable, and gardening is good for us."

As one who minds the collective psyche of Star City, she reports that negativity is minimal; in fact, she describes a general optimism she attributes to a

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The Soviets launched 48 missions from the Plesetsk cosmodrome in 1990, including this Soyuz rocket, which carried a recoverable Photon capsule for microgravity experiments. Plesetsk, however, cannot accommodate the big rockets in the Proton family, which must launch from the Baikonur facility in what is now the independent state of Kazakhstan.

metaphysics available only to spacefarers. "Space exploration has given us a mechanical link and, more importantly, a spiritual link with the universe. We understand more of our place in the universe now than we did just 30 years ago...maybe even with the cosmic mind people call God." She smiles. "This place comprises a typical cross-section of humanity. We have ordinary difficulties and disagreements. But we all agree that it would be unworthy of man to abandon a learning process of such magnitude."

Should the Russians abandon space, man's longest-running experiment on human behavior would be left undone. The Soviet medical and psychological records constitute a vast store of information on how humans endure long periods of weightlessness and isolation. It is a priceless collection of data for any nation with aspirations to travel to Mars or beyond.

"For any country to duplicate this kind of study would be a monumental waste of resources," says Gennady Strekalov, who has spent more than one and a half years in orbit. He swigs a beer in his comfortable Moscow flat and continues his commentary on a video he made during his most recent year orbiting in the Mir space station. "We put pants on for these shots," he laughs, "but usually we were naked out there."

Strekalov's recollections include watching the Kuwaiti oil fields burn and seeing the night-lit capitals of England, Spain, and France all at once through the same window. He describes watching the colors of the northern hemisphere change through all four seasons. His all-embracing view left him with little patience for boundary maintenance on Earth. "We must internationalize the efforts to explore space," he says. "Dickering over which country can charge how much per kilo launched won't help exploration." Strekalov's film, *Flesh of the Earth,* shot from orbit, was used to open the Earth Summit environmental conference in Rio de Janeiro last June.

"Eventually, if democracy works in Russia, the people's perceptions of the value of spaceflight will determine the extent of Russia's role," Strekalov says. He worries that cosmonauts are regarded as faceless pawns who served only cold war purposes. "Russian people are tired of the space program. We should be promoting the benefits of exploring Earth from space."

Troubled by a dozen interviews remarkable mostly for their uncertainty and desperation—from the contemptuous Feoktistov to the defiant

Mishin—I drove one evening toward sunset through Moscow's endless rush hour to view the Cosmonaut Memorial. The memorial is a 15-story Stalinesque monument that stands near the now-defunct exhibition of the People's Economic Achievement. I wondered what would happen to the people I had been talking to over the past couple of weeks if a truly democratic Russian society emerged. If popular referenda determined spending priorities, would the people continue to fund manned space exploration? In the after-work bustle I looked for intelligent eyes, hoping to hear a citizen's opinion of the importance of space.

SOVFOTO

In the shadow of the gargantuan shrine, Maxim Myakashev, a molecular biologist, cavorted with his small son, Andre. Now and then Myakashev cast an appraising eye on the sculpture. Framed by a granite base, a half-block-long bronze frieze portrays stoic rocket scientists and a cosmonaut looking forever leftward. Above, a rocket-tipped curving wedge of stainless steel swoops high into the filthy Moscow smog.

Myakashev, who researches AIDS diagnosis at Moscow's prestigious Institute of Gene Biology, added the people's perspective: "Eating is our problem. We can't afford enough food for our family. Last winter my children cried with hunger. I collected broken eggs behind the egg shop, picked the shells out, and cooked them. People here, even scientists who realize the importance of spinoffs from space research, aren't convinced that manned space exploration is necessary right now." Like

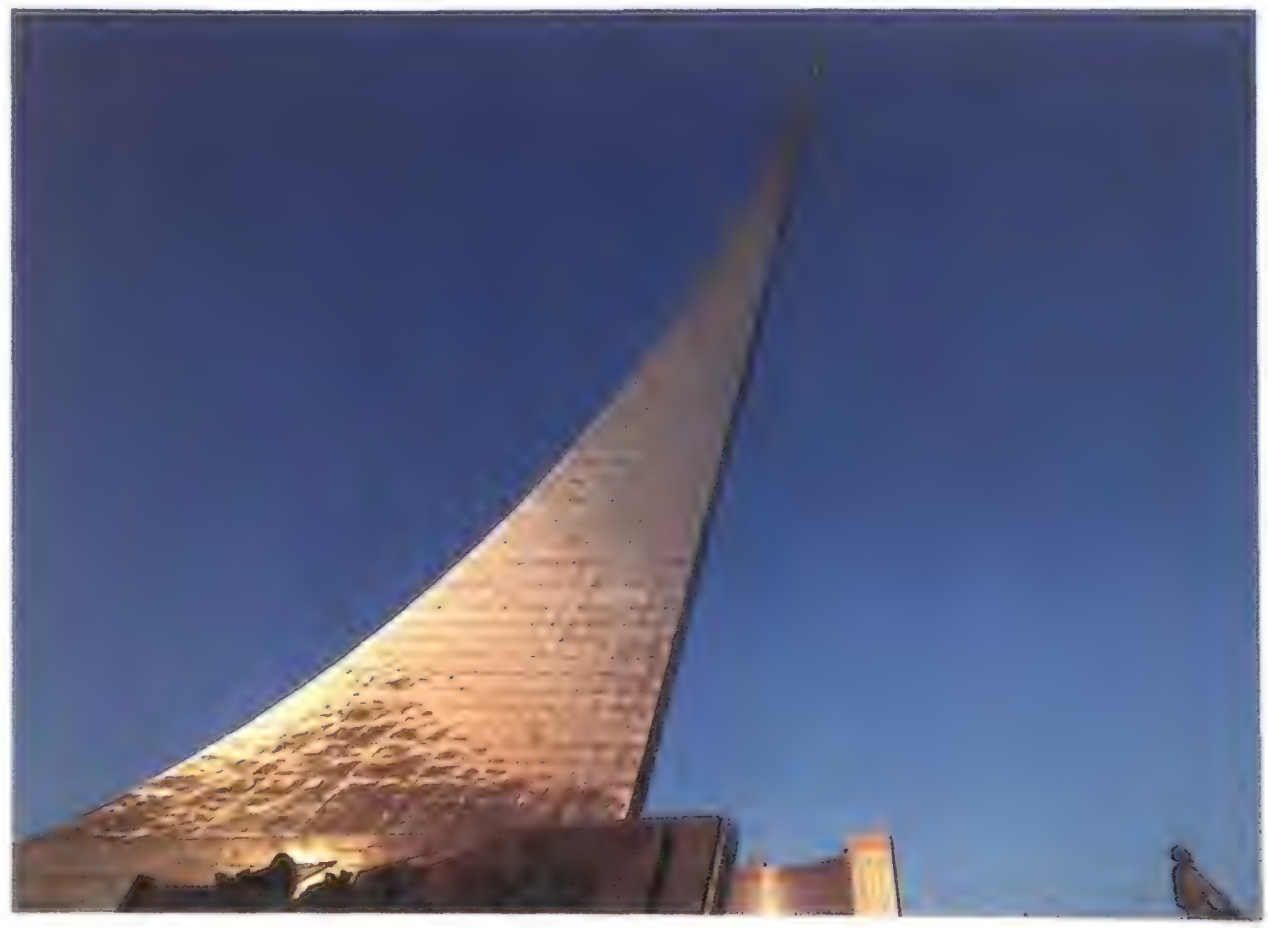
many Russians, Myakashev looked poorly fed and dressed, but dignified. He seemed to relish the long-denied freedom to speak his mind.

"Space programs have always been secret," Myakashev reflected. "Secret science doesn't serve people. Secret science fosters redundant research and corruption. If we vote, we'll abandon space for agriculture and other immediate economic needs." He paused and added, "I hope Americans aren't witnessing their own future in Russia. Can any single country justify men in space?"

Then, in an act as old and enduring as parenthood, he propelled his little son over his head into that split-second of weightlessness, gently settled him astride his shoulders, and headed for a subway entrance. ✈

A one man glee club, Pyotr Klimuk (above) runs Star City with optimism and grit. Much of his optimism comes from contracts with the French space agency to fly joint missions aboard Mir, like that of Soyuz TM-15 (left).

Anyone who looks on the Cosmonaut Memorial in Moscow today must wonder whether there remains in Russia the talent and will to continue the rocket's ascent.



V-2

The Long Shadow

It was responsible for the death of thousands, yet it also set us on the path to the stars. Fifty years after the V-2's first launch, Germany still struggles to reconcile itself with the rocket's dual legacy.

Story and photographs by Tom Huntington

From where I stand on the beach at Usedom Island, I can gaze out across the calm waters of the Baltic. Somewhere out there, on the bottom of the sea, lies whatever remains of the first successful ballistic missile. Launched from a German research facility at Peenemünde on October 3, 1942, the V-2 rocket arced upward for nearly 60 miles before plunging into the water 119 miles from its pad.

"It was an unforgettable sight," wrote Colonel Walter Dornberger, the army commander of the team that developed the complex missile, which would begin bombarding Allied cities almost two years later. "In the full glare of the sunlight the rocket rose higher and higher. The flame darting from the stern was almost as long as the rocket itself.... The air was filled with a sound like rolling thunder, the roar of the rocket motor just reaching us." Later Dornberger told his comrades: "We have invaded space with our rocket and for the first time—mark this well—have used space as a bridge between two points on the earth...."

In 1969 a direct descendant of the V-2 sent the astronauts of Apollo 11 on their way to the moon, showing just how far that bridge could reach. In fact, many members of the Peenemünde rocket team had been instrumental in creating the Apollo program's huge Saturn V, particularly Wernher von Braun. Even before the guns of World War II had begun to cool, von Braun and many of his colleagues had been snatched up by the United States and sent to work developing rockets. By 1969 he had risen to become head of NASA's Marshall Space Flight Center in Huntsville, Alabama, and one of the pivotal figures in the U.S. space effort.

Not everyone cheered Apollo's success unreservedly. "...I could not watch the Apollo mission," says Jean Michel, "without remembering that that triumphant walk was made possible by our initiation to inconceivable horror." Like Dornberger and von Braun, Michel had been involved with the V-2 during the war. However, he worked not at Peenemünde, in northern Germany, but at a concentration camp in the central part of the country. Arrested by the Germans for his role in the French Resistance, Michel had been imprisoned at a camp called Dora, which had been established to provide labor for V-2 production. Prisoners, most from the countries occupied by the German army, constructed the missiles in an underground hell in which thousands succumbed to ex-

COLLECTION OF PETER ORDWAY

The V-2 rocket, a weapon designed to force the Allies out of the war, undergoes field trials at the north German facility where it was developed. Today the nearby town of Peenemünde (inset) wrestles with the V-2's conflicting history of human achievement and human suffering.

haustion and malnutrition. In fact, nearly four times as many people died building the V-2 than in the missile's attacks.

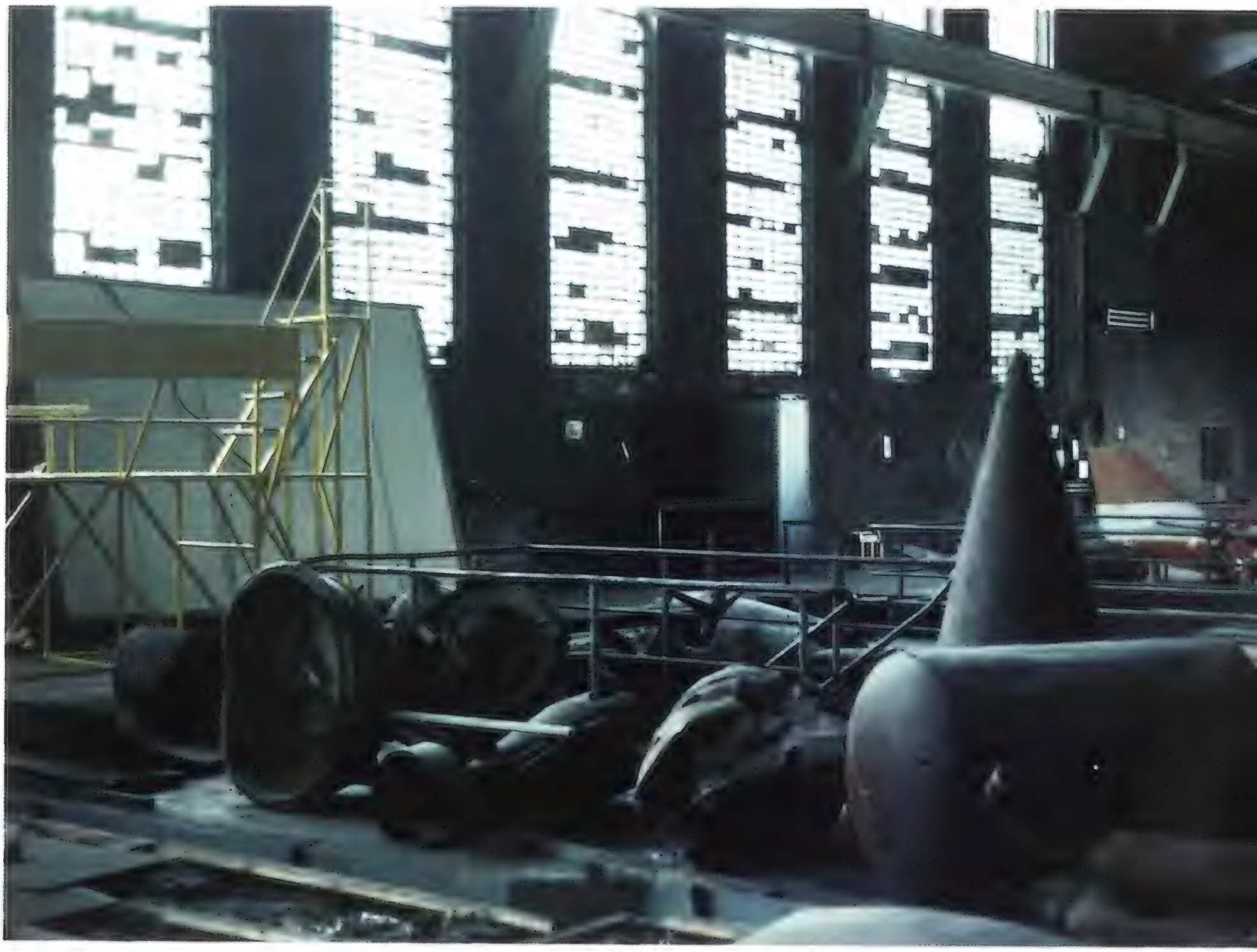
World War II ended almost 50 years ago, but still Germany struggles to come to terms with horrors like Dora. There's a word for the process, one of those supernouns so intimidating to non-Germans: *Vergangenheitsbewältigung*, or "mastering the past." Every so often, Germany's continuing unease with its history resurfaces. Consider the furor churned up in 1985 when then-president Ronald Reagan visited the Bitburg cemetery, which contains the graves of 49 SS troops. Last year, Robert Harris' detective novel *Fatherland*, set in a world in which the Nazis won the war and kept the Holocaust secret, became a best seller in England and the United States but was not even published in Germany. And the recent outbreak of neo-Nazi violence against foreign refugees in German cities has once again stirred the nation and the world to reexamine Germany's past and its impact on the present.

In the years since the nation launched the first successful V-2, German society has suffered two cataclysmic events: first, in 1945, it was divided into East and West following the

COLLECTION OF FRED ORDWAY

Colonel Walter Dornberger (left) and Wernher von Braun share a congratulatory telegram following the V-2's first successful launch on October 3, 1942.

Remains of V-1s and V-2s clutter Peenemünde's former power plant, now used by a V-2 museum for storage.



defeat of Adolf Hitler's Third Reich; then, in 1990, the country was reunified. Both Peenemünde and Dora were in the East and had been largely inaccessible to visitors from the West. Today, as Germany wrestles with the financial and emotional issues of reunification, people in both former V-2 sites are working on memorials that concern the historic rocket. But the differences between the two efforts symbolize some of the difficulties Germany has had dealing with the legacy of the Nazis and the war. At Peenemünde, a museum concentrates on the technological achievement the V-2 embodied. At Dora, the staff at the concentration camp memorial strive to illuminate the dark side of that accomplishment.

The sign outside Peenemünde's Informationszentrum bills the site as the "Cradle of Spaceflight." It also plugs the Feldsalonwagen, an Army field canteen turned into a café with "quality kitchen, coffee, cake and ice cream." This is no longer East Germany, and today's Peenemünde clearly doesn't mind mixing history with a little capitalism. Parking at the museum costs 3 deutsche marks (about $2), admission is another DM 3, and if you want to take pictures, there's an additional fee of DM 1.5. A souvenir stand offers items like postcards and mugs with an image of a V-2 rocket in flight.

In April 1937 a wunderkind named Wernher Magnus Maximillian Freiherr von Braun, then 25 years old, arrived here with an assortment of assistants to take rocket research to a higher level. Their funding came from the German army, which had become interested in rockets in part because they hadn't been forbidden by the Treaty of Versailles. The team's army commander was Dornberger, but the real technical genius was von Braun, whom Dornberger had hired in 1932. When the team had begun searching for a more spacious and isolated location for their testing, von Braun's mother suggested Peenemünde, a small village on Usedom Island where her father had often gone duck hunting. Lying at the mouth of the Peene River, it was surrounded by thick woods that would provide privacy for the rocket team. At its peak, the establishment employed nearly 2,000 scientists and engineers.

COLLECTION OF FRED ORDWAY

Little has changed on the island in the years since von Braun and his team left to surrender to the Americans. Kept relatively sheltered from development by the Iron Curtain that descended when Soviet troops arrived in March 1945, it has little of the garish beach culture that one would see at a coastal community in the United States. The narrow road to Peenemünde provides glimpses through tall pines of the dunes that line the beach. Here and there cars are parked along the road. Their owners can be found, often nude, on the white sand beach, despite signs warning of unexploded bombs left over from the war.

Peenemünde itself is a quiet village with a population of around 400. Conspicuous among the blocks of spartan Eastern European-style housing is a large brick ruin, a shell of a building that used to be the plant where liquid oxygen was made for the thirsty V-2 rocket engines. Nearby are signs of the quiet revolution called reunification. Tied up in the little harbor beyond Peenemünde's old power plant are more than

Curator Peter Profe (above) hopes to use the Peenemünde museum to educate young Germans about space travel.

V-2 workers at Peenemünde, here in a components manufacturing shop, included thousands of prisoners.

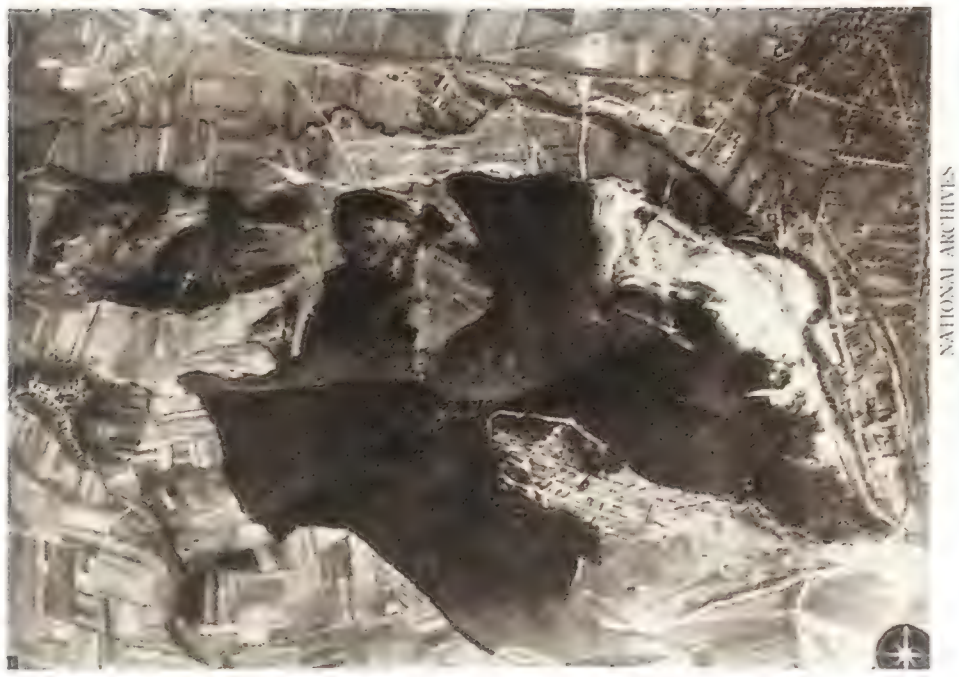
two dozen naval vessels—relics from the East German navy—their guns and torpedo tubes covered with canvas. The runways at the air base on the tip of the island, where weapon systems like the Me 163 Komet were developed, are used to store army vehicles.

Much of the former research establishment at Peenemünde is still off limits because it lies within a German military base. I'm not allowed to visit the remains of Test Stand VII, the V-2's launch pad. It's a disappointment, although the Soviets razed most of the site under the terms of the postwar Potsdam agreement, so all that's left is broken concrete overgrown with trees and shrubs.

The museum, which opened in May 1990, is located in a small building that was originally the control room for the power plant. Inside, models, documents, and V-2 parts tell the history of the German rocket program, and a large diorama details the layout of the site. It's a modest museum, but according to its head, Peter Profe, it attracts 160,000 people annually.

On the grass outside are several Soviet-bloc aircraft, plus a mockup of a V-1 "buzz bomb." A forerunner of today's cruise missile, the V-1 was developed by the Luftwaffe and tested at the nearby air base. Dominating everything is the research compound's large power plant, a brick monolith that remained operational until 1990. When completed in 1942, it was the largest coal-fired plant in Europe, and the scrubbers and filters installed in its tall smoke stacks were so efficient that Allied photo interpreters planning bombing raids against Peenemünde didn't even know it was up and running.

Inside the plant, Profe slaps his hand against the brickwork in a stairwell, admiring the craftsmanship. "This will last a thousand years!" he says. Beyond, the plant's interior is a vast, dim space. Bits and pieces of rusted metal lie in heaps—the remains of V-1s and V-2s that have been dug up locally. A MiG-23 undergoing restoration sits nearby. In a cubicle behind it lies an engine from a British Lancaster bomber shot down during a British raid in 1943. A bent propeller testifies to the violence of the airplane's demise. Another Lancaster shot down the same night lies in a shallow lake not far from the plant.



NATIONAL ARCHIVES

Following Allied bombing of Peenemünde, V-2 production shifted to a factory deep inside central Germany's Kohnstein mountain (dark area). Housed in a depression in the mountain, a concentration camp called Dora supplied the factory's labor.

Dora curator Torsten Hess stands before the entrance to one Kohnstein tunnel that today is used to store beer.

Profe has grand plans for Peenemünde. "The plan is to build here something analogous to the American Space Camps," he says, where the emphasis would be on education. "No wild tourism, no Disneyland, but a pedagogical entity in which young people can be introduced to the useful aspects of space travel, not the destructive or military purposes. They should get practical experience underwater so they can experience the weightlessness of space, in a big water tank, and with rotating swings."

Profe, a veteran of the East German air force, hopes such a complex would revitalize the whole area, which, like much of the former East, was hit hard by reunification. Before the demise of communism, East German citizens were virtually guaranteed employment. Today, with the airfield closed, Peenemünde has an unemployment rate of 70 percent. The space park "will allow us to build hotels, supermarkets, and so forth," Profe says. "It will have to be built so that people can find work again."

Profe's hopes for the future seem still more grandiose when you consider that the museum doesn't even have its own V-2, just a one-third-scale model. And he acknowledges that right now the money isn't there. "The project study itself will cost about a half-million German marks, but all in all we estimate 20 to 25 million marks," he says. And this at a time when Profe can't even afford to fly to London to see the V-2 artifacts at the Imperial War Museum.

Outside Peenemünde, some feel that any V-2 museum would do more harm than good. The uproar over German plans to commemorate the 50th anniversary of the October 1942 launch demonstrated how inflammatory the subject is. The ceremony, scheduled for October 3 and organized by the German Society for Aeronautics and Astronautics, was scaled back following protests in

Britain that labeled it "callous" and "despicable." More than 2,700 Britons had been killed in V-2 attacks. "The idea itself of celebrating the 50th anniversary of the rocket's invention, achieved at such a high cost in human lives, was so preposterous—nay, perverse—that it makes one shudder," one survivor of a V-2 labor camp wrote the *New York Times.*

But Frederick Ordway III, co-author of the V-2 history *The Rocket Team,* urges another perspective. "Sure, it was one of Germany's major weapons systems," he says, "but that doesn't make it good or bad, I don't think, just like atomic energy is one of our major weapons systems. I think it's tragic that we moved into the nuclear age via dropping bombs...but the fact that we moved into that age, I think, in the long range is going to be very beneficial."

What remains inarguable is that the V-2 was a giant leap forward for rocketry. "It's fundamental," says Michael Neufeld, a National Air and Space Museum curator who is working on a book about the V-2. "It really is the grandfather of both missile development—ballistic missiles—and space boosters." Its inventors had to master a number of complex technologies—fuel injectors, stabilizers, control systems—and get them to work together in a rocket that stood 46 feet tall, weighed 14 tons, and was propelled by an engine that could develop 25.4 tons of thrust.

The difficulties the rocket team had to overcome, Dornberger told American interrogators at the war's end, "were similar to those which would have faced Wilbur Wright if one had demanded of him in 1902 that he build in three years a completely automatic flying fortress."

As a weapon, though, the V-2 was largely a waste of money and resources. The rocket could deliver a one-ton warhead to its target, but Allied bombing raids were dropping thousands of times that on Germany every day. Even Albert Speer, the Reich's minister of armaments and munitions and long a backer of the V-2, later confessed that it had been one of his greatest mistakes. "Our most expensive project was also our most foolish one," he wrote in *Inside the Third Reich.* "Those rockets, which were our pride and for a time my favorite armaments project, proved to be nothing but a mistaken investment."

So why did Germany go ahead with it? "It's not an easy question to answer and I am still scratching my head on it to some extent," says Neufeld. "At least before mid-'41 the army pushed this thing without Hitler's great enthusiasm or support. At that stage [Hitler's lack of interest] mattered less because the army still had more power and they wanted to push it. Later in the war it becomes crucial that Hitler seized upon this idea, the idea of revenge for the bombing raids on German cities and the idea that somehow he could change the course of the war by applying terror bombing of some kind.... Certainly it was a fantasy and he grasped onto it like a life raft." It was at this time that the rocket, known to its in-

As is true for most of former East Germany, economic hardships daunt the nearby town of Niedersachswerfen.

ventors as the A-4 (*Aggregat*—"machine unit"—4), was, for propaganda purposes, christened the V-2. As with the V-1, the "V" stood for *Vergeltungswaffe*: vengeance weapon.

Although the Peenemünde museum's overwhelming emphasis is on the success of the technology, the dark side of the V-2 isn't completely neglected. One corner of the museum is devoted to the subject of the slave labor pool at the later V-2 complex in central Germany. But there were slave laborers at Peenemünde too: as many as 5,000 of them were quartered in nearby Trassenheide. These prisoners, lumped in the euphemistic category "foreign workers," were largely captured Poles and Russians, employed on the project in violation of the Geneva Convention. More than 700 of them died in Operation Hydra, a British attempt to bomb Peenemünde out of commission on the night of August 17, 1943. Today there is a memorial to the dead prisoners outside Karlshagen, a village between Trassenheide and Peenemünde.

Test firings continued from Peenemünde until February 1945, but the research center's V-2 work was essentially finished by the bombing. Damage was surprisingly light, but production was shifted elsewhere, to a network of underground tunnels in central Germany called Mittelwerk ("central works"). To ensure a continuous supply of workers the Germans continued to use slaves, but on a much larger scale. They established a concentration camp. They called it Dora.

You reach Dora by turning off the main road between the towns of Niedersachswerfen and Nordhausen. Driving up the cracked pavement that leads to the camp, I can see a large indentation in the side of Kohnstein mountain to the right. Large chunks of rock lie at the bottom of the gash. A tiny sign marks this as the site of the south entrance to Stollen A, one of the two main tunnels of Mittelwerk. In 1948 the Russians tried to destroy the entire underground complex but had to be satisfied with merely bringing down the entrances. Past the tons of earth and rock, the Mittelwerk complex is still intact. There's a new entrance being dug near the A tunnel, and if all goes according to plan, a portion of the infamous underground factory should be open to the public this year.

Whereas the focus at Peenemünde is on the success of the rocket, the small staff at Dora wants to preserve the history of the accompanying horror. "We are not against Peenemünde," says Angela Fiedermann, 33, one of the memorial's curators, "but we are against some ideas of this museum.... I think they have forgotten that prisoners too worked in Peenemünde before the Kohnstein was used for the V-2. When the bombs fell, prisoners were killed. And they have forgotten that. They see only one side of this."

"The point here is to show both sides of [the coin], the black and the silver side of technical development of the rocket," says curator Torsten Hess. "Our main idea here is to show these sides: high technology and slavery work for the prisoners."

Today Dora is little more than a large expanse of gravel

Some 20,000 prisoners died at the Dora/Mittelbau complex during the war; a memorial at the site honors their memory.

Dora's crematorium (left), designed to burn 75 bodies a day, was unable to keep up with the camp's mortality rate.

Digging the tunnels was a hellish task; many of the prisoners were simply worked to death.

broken up by the foundations of old buildings. The barracks were all torn down or moved immediately after the war to serve as shelter for the people in Nordhausen whose homes had been destroyed by Allied bombs. A long black memorial wall stands at one end, facing a spur of Kohnstein mountain. In the woods above the camp a barracks is being rebuilt to show visitors what living conditions were like. There's another building on the hill in the woods, the sole survivor from the original camp. It's the crematorium, designed to burn 75 bodies a day, yet unable to keep up with the mortality rate at Dora and its dozens of satellite camps.

On a warm summer morning there is no one here but the birds. A large rabbit bounds by the half-built barracks. It's so peaceful, so pretty, that it's hard to conceive of this place as the site of many horrors.

Yet "the very name of 'Dora' was enough to drive prisoners to suicide rather than to go there," recalled Anton Luzidis, a Greek sea captain who was sent there and survived the war to testify to Allied prosecutors about the conditions. "The meaning of 'Dora' was: fright. I cannot find the proper words to characterize the conditions there. It often happened to me that I asked myself whether I was still alive in the world, or whether I was brought into this hell after my decease."

The complex consisted of the main camp, Dora, and 31 sub-camps in the area around Nordhausen. Until October 1943 Dora was run by Buchenwald, and when it became an independent unit the complex was given the name Mittelbau. Unlike such infamous death camps as Auschwitz, Dora wasn't established specifically to exterminate prisoners, nor was it largely populated by Jewish prisoners. Dora's inmates were a mixture of criminals, homosexuals, prisoners of war, and those imprisoned for political reasons, although the Jewish population rose once the advancing Soviet army forced the evacuation of camps to the east.

Dora's main purpose was to provide labor for the V-2 production lines beneath Kohnstein. A portion of the tunnels pre-dated the war. They had been dug out during mining of the mountain's interior and used to store gasoline and chemicals. After the site was selected to house V-2 production, slave laborers who were forced to live and work under the ground blasted out tunnels to create a gigantic complex. The main A and B tunnels, each large enough to accommodate two rail lines, stretched for nearly a mile through the mountain. Connecting the main tunnels was a system of 47 cross-passages, each 180 meters (nearly 200 yards) long and nine to 12 meters tall. The final complex was large enough to house production of the V-1 and V-2, as well as a Junkers factory for the assembly of turbojets.

Nazi Germany established a private company, Mittelwerk GmbH, to run the work in the tunnels. The company paid the SS four to six marks a day for each concentration camp prisoner employed there. It was administered by a group of directors, headed by Albin Sawatzki, who had proven his abilities as a production chief for tanks.

Hitler had hoped to launch 5,000 V-2s at London simultaneously, but more realistic production figures called for the Mittelwerk tunnels to deliver 900 a month. Production never reached that level, and at its peak the factory was able to produce slightly less than 700 a month. By the war's end, some 3,000 missiles had been launched operationally, most of them at London and Antwerp, killing a total of about 5,400 people.

NASM

Long before the first V-2 attack was launched in September 1944, prisoners were dying in the production effort. A briefing paper prepared for U.S. Office of Strategic Services head James B. Donovan, dated August 30, 1945, described the conditions the prisoners faced during the months when they dug out the factory complex: "On 3 January 1944 no less than 3,000 prisoners were sleeping in one single shaft. At that time ventilation had not yet been installed. The air was full of dust and it was so foggy that one could not see a few feet away. Demolition charges went off throughout the mountains at all times and stones fell on the sleeping men. The beds were always occupied, being used by both shifts. For months the prisoners did not get out of the mountain into the fresh air. For thousands of them there were no washing facilities and there were no toilets. There wasn't even any drinking water available and only rarely a small cup of thin 'coffee.' Many prisoners used their own urine for washing purposes. In January 1944 there was not a single latrine in the entire shaft. The prisoners relieved themselves simply where they stood and the shaft smelled like a sewer. Vermin was all over the place."

Conditions improved once the camp was constructed, and the death rate decreased somewhat. But beatings and hangings were routine. Prisoners accused of sabotage were sometimes hung 20 at a time from a crane inside the tunnels and left as an example to the others. According to a U.S. Deputy Judge Advocate's report written after the war, "Such minor matters as using a piece of scrap rubber to repair the sole of a shoe, using a scrap of leather or rope to make a trouser belt, making a ring or a spoon out of a scrap of aluminum, or using a discarded cement bag in lieu of underwear were considered sufficient acts of sabotage to justify hanging." Entering the tunnels for the first time, Greek captain Luzidis encountered nine hanged men. "Each of them had in his mouth a piece of wood at a length of about ten inches, fixed towards the back of the neck to make it impossible to cry or speak," he told war crimes prosecutors. "I was so much frightened at this sight that I was almost unable to walk on. At my sides were two countrymen, Psaropulos Georgios and Lidiropulos Georgios, who were as much frightened as I was. Psaropulos suddenly said to me: 'Oh God, Anton, our lives are soon to come to an end....' The other prisoners who stood there with us had longer been in the camp already. They smiled at us a little bit and said this: 'Ha! You have been frightened with such little things? This is just a trifle of what we have seen here, and what you will live to see yourselves very soon.' "

Of the 60,000 people imprisoned in the Dora/Mittelbau complex, at least 20,000 died. After the war Mittelwerk's civilian directors blamed the conditions on Sawatzki, who had disappeared sometime after April 1945. Rumors circulated that he was in Britain working on V-2 research, or helping the Americans with their German rockets. The Americans believed that he had been killed in Nordhausen in 1945. One thing is certain: at some point he was in American custody. A newspaper reporter who reached Dora shortly after the liberation wrote that American soldiers had captured Sawatzki and forced him to crawl up and down the lines of dead

COLLECTION OF FRED ORDWAY

Some 3,000 V-2s, here bearing a crude foliage camouflage, were eventually launched against Allied targets.

prisoners that had been laid out on the camp grounds.

Today, some 40,000 people visit the memorial at Dora each year. Established in 1964, it had become a mandatory stop for local residents of East Germany. The exhibit inside the crematorium, a holdover from communist rule, attempts to link Hitler to the interests of big business. "The old exhibition in the museum will be taken out and we only want to show what happened in this building," says Fiedermann. "That means an exhibition about the crematorium in the crematorium." Plans also call for public access to at least some parts of Mittelwerk.

Fred Rauskolb, an American lawyer who has lived in Germany for the past 20 years, visited the tunnels last year. Despite the Russian efforts to destroy it, "the place is mind-boggling," he says. "Apparently they did quite extensive blasting and the effects of that are visible today in the form of massive steel girders which have simply been bent around corners, things that have been thrown through the tunnel complex, and plates of, I believe, gypsum which have simply been peeled off the ceilings and the walls and thrown on the ground. Some of that is natural erosion and natural deterioration of the surfaces, but a lot of it is apparently attributable to the

blasting. And there's also a very fine film of residue of the explosives that is in certain areas all over the place, all over the ground. It's a slippery gray mass that is difficult to walk on." Water has seeped into the tunnels, and one portion is passable only in a rubber boat. "And there are parts which can be seen under water," Rauskolb says. "I saw a number of V-2 rocket engines which are totally submerged and seemingly in good condition."

At Dora, Hess shows me a videotape made in Mittelwerk. It's astonishing to see the number of V-1 and V-2 parts that remain, some almost rusted away, others in relatively good condition. The tunnels themselves, large and in some cases two-tiered, are like an underground lair for something unspeakable and inhuman from a science fiction movie.

The rocket may have been invented in Peenemünde, but it was exported from Mittelwerk. From there, "the rocketry and space technology was exposed to the world—to America, to Russia, to Great Britain, to the French," says Hess. Even as they worked together to defeat Germany, the U.S. and the U.S.S.R. were squaring off as rivals. Before giving up the Mittelwerk site to the Soviets, U.S. troops loaded 300 boxcars full of V-2 parts and shipped them back to the United States, where they could be studied, tested, and later used as precursors to the missiles that could carry World War II's second great technological achievement: the atomic bomb.

The United States also scored the greatest coup in terms of German rocket scientists. A top-secret government program, Project Paperclip, was established to snap up the best German researchers for work in the United States. Dornberger, von Braun, and most of the Peenemünde rocket team surrendered to U.S. troops on May 2, 1945. Within months they were set up at White Sands, New Mexico, to help develop rocketry for the United States. In the atmosphere of the Cold War, the unsavory backgrounds of some scientists were ignored. When the subject was mentioned at all, the German scientists were often portrayed as so blinded by the pure love of spaceflight that they were ignorant of the darker legacy of the V-2.

Yet von Braun had visited Mittelwerk 15 to 20 times. His brother Magnus was a civilian worker there. Arthur Rudolph, who later worked at NASA and was program manager for the Saturn V, was one of Mittelwerk's directors. In 1983 members of the Department of Justice's Office of Special Investigations gave Rudolph an ultimatum: either face a trial and possible deportation for war crimes related to his work in the tunnels, or give up his U.S. citizenship and leave the country. He chose the latter and now lives in Hamburg. (Rudolph declined to be interviewed; OSI director Neal Sher did not return repeated phone calls.)

"It's complicated," says National Air and Space Museum curator Michael Neufeld. "It doesn't boil down to a neat black-and-white picture of a bunch of goose-stepping Nazis or a bunch of head-in-the-clouds spaceflight enthusiasts." V-2 historian Fred Ordway, who worked with von Braun and other German scientists at the Army Ballistic Missile Agency and later at the Marshall Space Flight Center, says he discussed Dora with von Braun. "He didn't ever try to hide that there were atrocities going on in Nazi Germany," Ordway says. "He never tried to cover up his past at all.... But of course he also pointed out that you didn't do much objecting in Nazi Germany during the second world war."

The V-1 buzz bomb (above) once vied with the V-2 for funding, but the two weapons shared in destruction, together killing nearly 10,000 Allied civilians. Below, residents of Antwerp, Belgium, clear rubble after a V-2 attack.

COLLECTION OF FRED ORDWAY

Ordway also takes exception to the idea that the V-2 was responsible for all the deaths at Dora. "It's a huge exaggeration to say the V-2 was built on the skeletons of 20,000 workers," he says. "This is no exoneration of anybody, but the death toll even during the building of the tunnels wasn't exceptionally high." Ordway says most of the deaths occurred near the end of the war, after prisoners were transferred to Dora from camps in the east. In fact, he argues that the V-2 was good for the prisoners at Dora, because conditions at the camp improved once production began. "Maybe not for altruistic purposes—because they couldn't have exhausted, emaciated prisoners working on such high-technology projects," he says. "Once the V-2 came in, that was the salvation of the camp really. If you look at the records of the deaths they went down very, very low given the production period."

After the war, Charles Lindbergh was among the first Americans to visit the site, part of a U.S. Navy commission studying German war technology. He was appalled by the camp's crematorium. "We were standing at the edge of what had once been a large pit, about eight feet long, six feet wide, and I guessed at six feet deep," he later wrote. "It was filled to overflowing with ashes from the furnaces—small chips of human bone—nothing else. A trail of ashes ran over the edge of the pit toward the door of the furnace room. Apparently bucketsful had been thrown from a distance, as one might get rid of ashes on a coal scuttle on a rainy day."

"Those who cannot remember the past are condemned to repeat it." It's a hoary old maxim, perhaps, but it takes on new meaning now that concentration camps are being discovered in the Balkans and neo-Nazis are attacking foreigners in Germany. During the war in the Persian Gulf, Iraqi president Saddam Hussein took a page from Hitler's book and turned to the rocket as a weapon of terror. "It's the same historical and political situation," says Dora curator Torsten Hess. "Saddam Hussein was a dictator and Hitler also. And both take rockets to make war."

But how much of this past do Germans want to remember? Don't some feel that enough is enough? "Certainly that attitude is one you encounter frequently in Germany," says Fred Rauskolb, "but having lived over there for the last 20 years, I don't think there's any people that has been educated more thoroughly in terms of the public media as to what went on during those years. It seems that hardly a week goes by without a documentary or a docudrama or something that deals with the period in German history. That leads on the part of many people to the attitude of 'I don't want of hear about it anymore,' but by the same token has brought about, I think, in the minds of many a realization that this is a period of time in German history that can't be simply brushed under the rug, something that cannot be forgotten."

The Mittelwerk complex fought off one threat to history last year, when it deflected attempts by a gypsum mining company to expand its operations on the mountain and destroy part of the tunnels. "It's time to lower the curtain on our history," the mine's technical director told a Reuters reporter. "If we preserved every piece of the earth where the Nazis' prisoners died, economic development would be impossible."

"I think that a lot of people realize that there is a necessity to preserve this history," says Rauskolb, "and certainly the fact that the Dora/Mittelwerk complex is related so intimately with modern technology and rocketry and space exploration may be something which will cause a lot of people to think differently about this particular complex."

Perhaps. Without doubt, the V-2 was a pivotal development for rocketry and spaceflight, but one that left immeasurable ruin in its wake. "The height of human accomplishment and the depth of human degradation were there at the underground tunnels of Nordhausen," Charles Lindbergh wrote; "the two had somehow joined together to show the catabolic tendency of our civilization's science, which had produced Hitler's hellish V-2 rocket." Forged by war and produced through suffering, the V-2 also helped start mankind on the path to other planets. As Jean Michel, who survived the horrors of the V-2's concentration camp, wrote, "The escape into space had its beginnings in the burial of the living dead of Dora, who used to dream of impossible escapes...." ✈

Reunified Germany has new sources of turbulence—and, at Peenemünde, East German naval vessels it no longer needs.

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Victorian Holiday: England by Train June 17-28.

British Isles Cruise June 23-July 7.

NEW **Maritime England** July 1-13.

NEW **Musical White Nights (Russia and Finland)** July 3-15.

Iceland Adventure July 11-24.

Swiss Walks July 16-29.

Tibetan Journey July 21-August 7.

Canadian Rockies July 24-August 2.

DOMESTIC STUDY TOURS

Smithsonian "Anytime" Weekend (Washington, D.C.) Prices begin at $99 per person for a two-night package.

Death Valley April 4-13.

Arizona in Spring April 13-21.

Texas African Safari April 14-18 or April 28-May 2.

Grand Canyon Weekend April 22-25.

Footsteps of Coronado (New Mexico) April 25-May 1.

NEW **Historic Philadelphia** April 29-May 7.

NEW **Four Corners Archeology (Colorado)** April 30-May 7.

Okefenokee (Florida) May 1-6: Canoeing.

Spring Gardens (Delaware Valley) May 3-9.

NEW **Delta Queen** May 8-21: Pittsburgh to New Orleans.

Bryce, Zion and the North Rim May 9-19.

Hudson River Historic Homes May 15-20.

Arches and Canyonlands May 16-23.

Boston Weekend May 19-23.

Native Cultures of the Southwest (Arizona-New Mexico) May 23-June 2.

Grand Canyon Rafting May 28-June 6 or August 20-29.

NEW **Accessible Adventures** June-February: introducing a new series of outdoor programs designed for people with and without disabilities.

ODYSSEY TOURS

Low-cost tours (1993): Great Britain, Italy, France, Greece, Portugal, Spain-Morocco, Alps, Israel-Egypt, Belize-Guatemala, Canada and the United States. Six tours to Costa Rica will also be offered in 1993. For an Odyssey brochure only, call 1-800-932-8287.

SEMINARS

Writers and Key West (Key West, Florida) March 28-April 1.

Treasures from Ancient Greece (New York) May 13-16: See *The Greek Miracle* exhibition at the Metropolitan Museum of Art.

The New Astronomies (Tucson) May 16-21.

American Popular Song and Jazz (San Francisco) May 21-25.

Virginia's Historic Gardens (Richmond, Virginia) May 22-27.

Southern California Ecology (Santa Catalina Island) May 23-28.

Birds and Wildflowers (Jackson Hole) June 7-12.

RESEARCH EXPEDITIONS

Contribute your talent and financial support to Smithsonian research.

Curaçao, Netherlands Antilles March 6-21: Excavate remains of giant tortoises.

Washington, D.C. March 7-20: Work with the Tlingit Indian exhibition at the Museum of Natural History.

Annapolis, Maryland March 28-April 3: Record the everyday life of the Crow Indians.

Costa Rica April 17-29 or July 24-August 5: Monitor an active volcano.

THE LATEST WORD ON TOURS, EXPEDITIONS AND LEARNING ADVENTURES

BUILDING A LADDER TO THE MOON

Angle of Attack: Harrison Storms and the Race to the Moon *by Mike Gray. Norton, 1992. 304 pp., $22.95 (hardbound).*

Project Apollo was a gigantic enterprise, employing at its peak 400,000 Americans and costing some $24 billion. Like blind men touching an elephant, its participants recall different textures of the beast. Harrison Storms' hands were on one sturdy hind quarter, the Space and Information Systems Division of North American Aviation. Stormy ran the team that built the Apollo command and service modules, plus the second stage of the Saturn V moon rocket. He got fired after the launch pad fire that killed the first Apollo crew—Gus Grissom, Ed White, and Roger Chaffee.

This well-written book traces Storms' career with North American (he joined fresh out of college) from World War II up to the first moon landing in 1969. Now part of Rockwell International, North American Aviation was a premier aircraft house, builder of the P-51 Mustang, F-86 Sabrejet, XB-70 bomber, and the rocket-powered X-15. Stormy worked on most of these, proving to be a visionary design engineer and gutsy team leader. When the space program came along he slammed into it at supersonic speed, and his early efforts paid off. By 1962 he had won the command module contract over favored opponents, such as McDonnell Aircraft, builder of the Mercury and Gemini spacecraft.

Between 1964 and 1969, I spent a lot of time at Downey, California, the home of the Space and Information Systems Division. Mike Gray has definitely distilled the essence of the place, no doubt because of his 12 years of research and hundreds of interviews. Downey was a teeming beehive in the 1960s. At times it seemed the bees weren't quite sure which way to fly, but that wasn't altogether their fault.

The relationship between the division and its customer, NASA, was—how else to say it?—stormy. It reached its nadir after the Apollo fire, with each making a credible case that the accident was the fault of the other. This is where the story of Storms the elephant toucher and his scribe Gray founders a bit. At least I think so, but then I was working for NASA at the time and I may not be objective.

But I do remember Downey. Actually,

"SKY GARDEN" BY ROBERT RAUSCHENBERG © 1969 GEMINI G.E.I.

there were two Downeys, both of Stormy's making. First was the customer relations department, the carpet so thick under your feet that you felt you were on safari as you peered through the indirect lighting at the massive desk of the receptionist, a former Miss California.

The message on the shop floor was less clear. A lot of highly skilled technicians were working their hearts out, preparing command modules for flight. But others were clustered on the side, discussing weekend plans for lofting their campers into the High Sierras or onto the sand at Malibu. I never could figure out which faction had control of the operation.

In this book neither Storms nor Gray tells you that prior to the fire some of the work at Downey was sloppy—very sloppy—and it wasn't all NASA's fault. Gray gives a cursory nod to NASA, but clearly he is on Storms' side. I can't fault him for that since this is Stormy's book, but I would like to take a look at the whole elephant.

Angle of Attack also suffers from some annoying mistakes. Storms' name is misspelled on the spine, as is Wernher von Braun's on the flap copy. Those are the publisher's fault, but Gray makes some errors of his own. He writes that I was the first person to dock in space, when that honor belongs to Neil Armstrong and David Scott on Gemini 8. Gray also has an annoying habit of carefully identifying months but not years. Yes, April, but dammit, *which* April? Also, the book might have explained better why North American won the command module contract. What were the technical virtues North American offered, and how did they surpass those of the competition? I missed that.

Despite these shortcomings, Mike Gray does a first class job of explaining complicated technical issues and the people behind them in clear and interesting language. For instance, I think this is good writing: "A design engineer is an oxymoron—a disciplined dreamer. He must be able to completely grasp the current technology without being imprisoned by it; he must be able to scan the horizon of discovery and make the unexpected connections. Storms himself was a good designer; he had the soul of an artist, and he was at his peak when he was orchestrating a team of artists."

I recommend *Angle of Attack* highly to

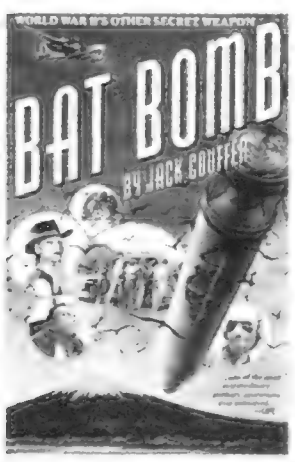
anyone looking for a most readable account of one man's race to the moon.

—Michael Collins is a former Gemini and Apollo astronaut and author of the forthcoming book Space Machine, *to be published by Grove Press.*

Bat Bomb: World War II's Other Secret Weapon *by Jack Couffer. University of Texas, 1992. 252 pp., b&w photos, $24.95 (hardbound).*

Remember the Japanese scheme of sending bomb-carrying balloons to drift across the Pacific and set fire to our forests during World War II? Pretty wild, right? Well, it turns out that we Americans came up with a caper that was considerably battier: bomb-carrying bats.

This is the story of a project initiated right after Pearl Harbor by Lytle S. Adams, a "cherubic and ruddy-faced, small and plump" dentist by trade and insatiable inventor by avocation. Adams was responsible for the pickup system that enabled an airplane to snatch up a bag of mail while in flight. Now his notion was to clip tiny incendiary bombs on a bunch of bats and drop the little mammals over Japan in container bombs that would release them at a certain atmospheric pressure. Then they would flap happily



down to find shelter in the crannies of crowded, highly flammable Japanese industrial centers. Bingo! Instant firestorm. A cheap, effective weapon delivery system—if a little hard on the bats.

Thanks to Eleanor Roosevelt, who knew Adams, the suggestion reached FDR and was passed along to the big brass with the notation: "This man is *not* a nut." So an unlikely group of mavericks, including zoologists, chemists, marines, a movie actor, and one of Al Capone's hit men, was recruited to get the project going under Doc Adams' exuberantly unmilitary leadership.

The author, then a museum lab assistant fresh out of high school in California and nuts about bats, was one of what might be called the B-team. Jack Couffer is now an old-time film producer-director-writer, and his book comes across like a top-notch, off-beat movie—*M*A*S*H* in a bat cave.

It's got horror: trying to photograph millions of roosting bats and being deluged by a downpour of bat urine as they all awake at once in the sudden glare of light. It's got intrigue: carrying on a small, subversive war with the military, which of course considered the concept to be full of guano. It's even got love, sort of, what with the author's virginity up for grabs.

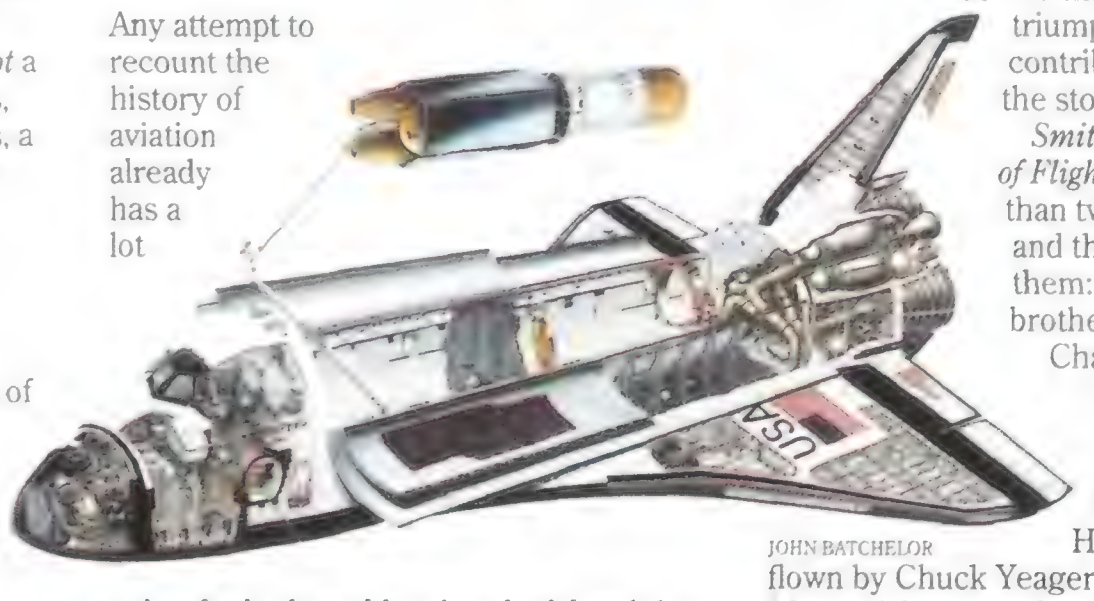
And did the concept work? Read this funny, fascinating, quite delightful book to find out. I'll reveal only that in one case the bats wiped out a complete airfield. Trouble was, the airfield was in New Mexico.

—Edwards Park is a contributing editor to Air & Space/Smithsonian.

Smithsonian Frontiers of Flight *by Jeffrey L. Ethell. Orion, 1992. 256 pp., color and b&w photos, $40 (hardbound).*

Any attempt to recount the history of aviation already has a lot going for it: the subject is colorful and the personalities charismatic. With its entertaining text and handsome photographs, *Smithsonian Frontiers of Flight* doesn't disappoint. It's the companion volume to the 13-part television series of the same name broadcast last autumn, which was co-produced by the Discovery Channel and the National Air and Space Museum. As the jacket copy promises, the book "celebrates the milestones in the history of flight by profiling the aircraft chosen by the curators of the National Air and Space Museum as the most important in their matchless collection."

Organized chronologically around eras of flight, the book spans 66 years—a remarkably brief time considering all of the ensuing accomplishments. As aviators break one record after another (although not without tragic missteps) the narrative gathers an irresistible momentum. Certainly the do-it-yourself philosophy behind many of the triumphs also contributes to much of the story's appeal.



JOHN BATCHELOR

Smithsonian Frontiers of Flight features more than two dozen aircraft and the people who flew them: the Wright brothers and their *Flyer*, Charles Lindbergh's *Spirit of St. Louis*, Wiley Post's *Winnie Mae*, Howard Hughes' H-1, the Bell X-1, flown by Chuck Yeager, and many others. Many of the more than 300 photographs depict various aircraft at different stages: in their prime, during restoration, and in the museum. The photographs guarantee that *Smithsonian Frontiers of Flight* will

VIDEO

The Ten Thousand Night Dream *by R. Mike Mullane, 1991. 42 min., available from R. Mike Mullane, 1301 Las Lomas Road, NE, Albuquerque, NM 87106; $33.76 (includes postage).*

Among the most sought-after entertainment at aerospace industry functions is a presentation called "The Ten Thousand Night Dream." Performed on a bare stage by former shuttle astronaut Mike Mullane, this 40-minute dramatized monologue takes viewers through the 36 hours before a shuttle launch. Recently one of these performances was videotaped, and the result is now available to the public.

Mullane, a veteran of three shuttle missions (and the author of "The Beach House" in the June/July 1992 issue of this magazine), calls the production "a glimpse into an astronaut's soul." Based on excerpts from a diary kept by the astronaut and his wife Donna, the performance—a montage of experiences from his shuttle flights—recounts the feelings of the couple as they count down the hours leading up to Mullane's last launch in 1990. Settings include the astronauts' secluded beach house retreat, the spartan quarters where crew members sleep, inside the cockpit of a screaming T-38 trainer jet, and aboard the shuttle in the minutes before and after liftoff.

Rough editing and clumsy sound effects mar the production, yet few astronauts have ever shared their emotions and the sights and sounds experienced in the minutes before a launch as candidly or vividly as does Mike Mullane in *The Ten Thousand Night Dream.*

—Beth Dickey writes about the space shuttle for Reuters News Service.

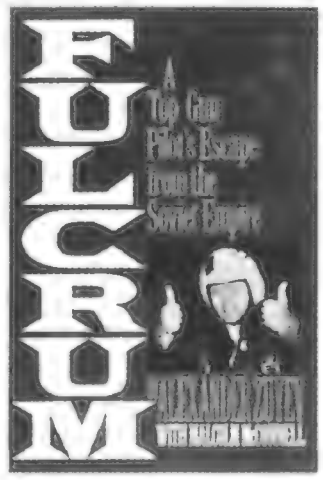
look good on the coffee table, but in addition, author (and *Air & Space/Smithsonian* contributor) Jeffrey L. Ethell, who has written more than 40 books on aviation and is a veteran pilot as well, offers up the history skillfully. Readers will find an insightful text that interweaves human, financial, industrial, and military history.

Smithsonian Frontiers of Flight ends with *Voyager* and its round-the-world unrefueled flight, an event that "distilled the essence of all that has made American aviation great." It's a description that could also be used for this book.

—David Savold is an associate editor at Air & Space/Smithsonian.

Fulcrum: A Top Gun Pilot's Escape from the Soviet Union *by Alexander Zuyev with Malcolm McConnell. Warner Books, 1992. 358 pp., b&w photos, $19.95 (hardbound).*

Fulcrum is a true-life story that rivals the best techno-thrillers. It's the story of a daring young Russian pilot who hijacked a frontline MiG-29 fighter from an air base in Soviet Georgia on May 20, 1989. Though wounded in the arm during a gun battle with an airfield security guard, Alexander Zuyev managed to elude pursuit as he sped across the Black Sea en route to asylum in Turkey.



Before his defection, Zuyev was in one of the first units to be equipped with the MiG-29 Fulcrum and was in line to become a military test pilot. He provides a wealth of detail about this top-line fighter, which is now being offered for sale to many Third World nations by a cash-hungry Russia. There is also an interesting vignette of superpower espionage concerning a mole for the United States in the MiG-29 program, as well as fresh insights into the events leading to the Soviet air force's downing of Korean Airlines flight 007 in 1983.

The book also traces Zuyev's career from his academy days to his posting with a frontline unit that saw combat in Afghanistan. Zuyev exposes much of the myth and mystique of the Soviet air force and provides insights into its operations.

But *Fulcrum* is more than a story of air

combat training and cutting-edge technology. It's also a tale of the gradual disillusionment of a young Soviet military officer—a tale that mirrors the political and social turmoil that eventually ripped the Soviet Union apart soon after his defection. Zuyev recounts the encounters with bureaucratic corruption and political oppression that led him to abandon a promising career.

This is a book not only for military aviation fans but also for those who wish to learn more about the popular backlash that toppled an empire.

—John D. Morrocco is senior military editor for Aviation Week & Space Technology.

Back in the U.S.A.

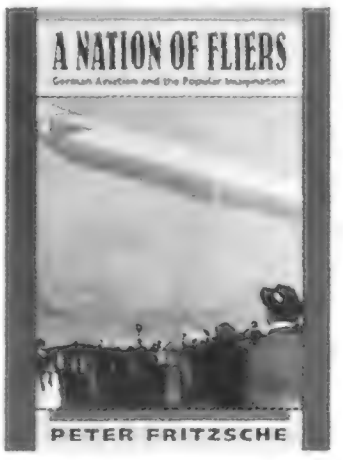
More than three years after his daring escape from the Soviet Union, Alexander Zuyev's life in America is gaining some normalcy. Today he lives with his mother and younger stepbrother outside Washington, D.C., in northern Virginia. His "official contacts" with the U.S. government are not as intense anymore. In addition to working toward his American citizenship, he is studying for his airline transport pilot rating.

After his defection, Zuyev spent a year being debriefed by U.S. intelligence officials and two years working with U.S. military pilots, instructing his former adversaries in Soviet aircraft and tactics. Perhaps Zuyev's most valuable contribution has been his knowledge of Soviet air defense capabilities. "Because of my work," he says, "the U.S. Air Force canceled a classified project to upgrade its airplanes that could have cost the U.S. taxpayers $700 million."

The value of Zuyev's knowledge did not diminish with the end of the cold war. During Desert Storm, U.S. pilots tapped his knowledge of the MiG-29 and Soviet tactics, both used by the Iraqi air force. The former Soviet fighter pilot wasn't surprised by the performance of the Iraqi pilots. "I knew their [Soviet] instructors and what they knew," says Zuyev. "They were graduates from aviation academies—great theorists with little practical experience beyond basic tactics and maneuvers." About the Iraqi pilots he says, "All Iraqi MiG-29 units were staffed through family connections. You didn't have to fly like an eagle to be a MiG-29 pilot in Iraq."

A Nation of Fliers: German Aviation and the Popular Imagination *by Peter Fritzsche. Harvard University Press, 1992. 282 pp., b&w photos, $27.95 (hardbound).*

On August 5, 1908, a summer squall set off an explosion that destroyed airship LZ4 (Luftschiff Zeppelin 4) at Echterdingen, near Stuttgart. This disaster brought about a massive outpouring of public support for Ferdinand Graf von Zeppelin, which became a watershed event for German aviation known as the "Miracle at Echterdingen." Peter Fritzsche's skillfully written and well-documented book begins with a description of the zeppelin craze and then explores the effects of aviation on German culture in an important period of nationalistic technological development.



Fritzsche takes the reader from Echterdingen through World War I to the postwar period, when Germany turned to gliders to counteract the Allied-imposed limitations on aircraft construction and to assert a new and fervent sense of nationalism. The creation of a national airline, Luft Hansa, the advent of a new generation of zeppelins in 1924, and the impressive successes of transatlantic airship flights all conjured up dreams of a German rebirth led by a legion of fliers. These lofty dreams, however, were appropriated by the Nazis and transformed into an authoritarian airmindedness that presaged the tragedy to come during World War II.

Fritzsche's book is especially welcome because of its focus on the social, cultural, and political ramifications of aviation in a pivotal period of its development. One would welcome similar books on all the significant air powers—Great Britain, the United States, Italy, France, and the Soviet Union—that saw aviation as more than a technological *tour de force* in the 1920s and 1930s.

—Dominick A. Pisano is deputy chairman of the aeronautics department at the National Air and Space Museum and the author of the forthcoming "To Fill the Skies with Pilots": A History of the Civilian Pilot Training Program *(University of Illinois Press).*

CALENDAR

February 8–13
"Larry: Cat in Space." The cinematic adventures of a cat who sneaks off to a moonbase. Plus "The Night Skies of February" star talk. Robert H. Goddard Planetarium, Roswell, NM, (505) 624-6744.

February 21 & March 21
"Open Cockpit Sunday." World War II and modern fighters. New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

March 1–3
"1993 Upper Midwest Aviation Symposium." Seminars, workshops, exhibits. Radisson Inn, Bismarck, ND, (701) 224-2748.

March 4–6
"Women in Aviation Conference." Sponsored by Parks College of St. Louis University. Hyatt Regency in Union Station, St. Louis, MO, (618) 337-7575, ext. 203.

March 22–27
"Space Dreams." The past and future of spaceflight. Plus "The Night Skies of March" star talk. Robert H. Goddard Planetarium, Roswell, NM, (505) 624-6744.

March 25–26
"Presidential Leadership, Congress, and the U.S. Space Program." Symposium sponsored by American University and NASA's History Division. American University, Washington, DC, (202) 358-0384.

March 30–April 25
"The View From Space: American Astronaut Photography, 1962–1972." Smithsonian Traveling Exhibition. Roswell Museum and Art Center, Roswell, NM, (505) 624-6744.

CREDITS

DC-6 Heavy. As an Air Force R&D officer, William C. Walter was the first manager of the Dyna-Soar program, the predecessor to the space shuttle. Currently he is vice president and chief engineer of Hybricraft Corporation.

Back in the Saddle. Alex Nelon is currently somewhere at 41,000 feet.

An Industry Held Hostage. William Triplett is co-author of *Drug Wars: An Oral History from the Trenches*, which was recently published by William Morrow. His last article for *Air & Space/Smithsonian* was "SETI Takes the Hill" (October/November 1992).

Further reading: *Terrorist: The Inside Story of the Highest Ranking Iraqi Terrorist Ever to Defect to the West*, Steven A. Emerson and Christina Del Sesto, Villard Books, 1991.

I Came, I Saw, I Lost. Contributing editor Stephan Wilkinson is currently modifying his homebuilt Falco to carry two collapsible bikes.

Special Delivery. Preston Lerner's last contribution to *Air & Space/Smithsonian* was "Stall Tactics" (April/May 1991).

Further reading: *Howard Hughes and His Flying Boat*, Charles Barton, Aero (division of TAB Books), 1982.

The Case of the Missing Matter. M. Mitchell Waldrop is a contributing correspondent for *Science* magazine. His book, *Complexity: The Emerging Science at the Edge of Order and Chaos*, was published last year by Simon & Schuster.

Can Russia's Space Program Survive? Tom Harpole's last story for *Air & Space/Smithsonian* was "Leap of Faith" (October/November 1992). That story, which described Harpole's first jump with a Russian skydiving champion, was translated into Russian and published in the Moscow-based newspaper *Space Year*.

V-2: The Long Shadow. Tom Huntington is managing editor of *Air & Space/Smithsonian*.

Further reading: *The Rocket Team*, Frederick Ordway III and Mitchell Sharpe, MIT Press, 1982.

Secret Agenda: The United States Government, Nazi Scientists, and Project Paperclip, 1945–1990, Linda Hunt, St. Martin's Press, 1991.

Model Students. Elaine de Man is a journalist who explores Alaska and the west from the right seat of a Cessna 170B.

"The Satellite Sky" Update/34

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

- Cosmos 2220 11-20-92 PL
- Cosmos 2223 12-9-92 TT
- Progress M-15 10-27-92 TT

300 to 630 MILES

- Cosmos 2218 10-29-92 PL
- Cosmos 2219 11-17-92 TT
- Cosmos 2221 11-24-92 PL

630 to 1,250 MILES

- Cosmos 2211-16 10-20-92 PL

3,100 to 6,200 MILES

- Lageos 2 10-22-92 KSC

6,200 to 13,700 MILES

- GPS-16 11-22-92 CAC

21,750 to 22,370 MILES

- Ekran 20 10-30- 92 TT
- Galaxy 7 10-28-92 KOU
- Gorizont 27 11-27-92 TT
- Superbird A 12-1-92 KOU

DATA: SAUNDERS KRAMER

Deletions

90 to 300 MILES

Almaz
down 10-17-92

Cosmos 2210
down 11-20-92

Foton 5
down 10-24-92

FSW-1
down 10-31-92

Progress M-14
down 10-21-92

Launched but not in orbit

90 to 300 MILES

CTA Canada research	10-22-92	down 11-1-92
STS-52 U.S. research	10-22-92	down 11-1-92
STS-53 U.S. research	12-2-92	down 12-9-92

Inoperative but still in orbit

300 to 630 MILES	21,750 to 22,370 MILES	
Cosmos 2154	Telecom 1A	Gorizont 15

FORECAST

In the Wings...

The Search for Planet X. Even after Pluto was discovered in 1930, some wondered if our picture of the solar system was complete. Today astronomers still search for an elusive 10th planet.

Packing Up the Final Frontier. The National Air and Space Museum's Star Trek gallery was the most popular exhibit in the Smithsonian's history. The volunteers who worked the front lines attempt to explain why.

Race to the Sun's Edge. The days of planetary encounters are over for the Pioneer and Voyager space probes, but that doesn't mean their missions are finished. The next stop: the end of the solar system and the beginning of interstellar space.

Stewardess No More. Today's flight attendants—male and female—struggle with stereotypes from the past as they attempt to define their future with the airlines.

Looking for Quentin. Theodore Roosevelt's son Quentin answered patriotism's call and became a pilot during World War I. Shot down and killed, he was mourned nationwide, yet his final resting place was almost forgotten until one man set out on a quest to find it.

JOHN HEINLY

Model Students

Reid-Hillview Airport, which sits on the edge of Northern California's Silicon Valley, is surrounded by housing tracts and swimming pools that are encroaching on the few farms left hugging the hillsides. There's a huge recreational water slide on the downwind leg, a massive shopping mall on final approach, and two mini-storage facilities opposite the control tower. There's also a parking lot along the chain link fence at the end of the runway where parents bring their kids to watch the airplanes come and go.

Fifty years ago, when the airport was ringed with dairy farms and fruit orchards, an earlier generation of children may have stood on the same spot. After the attack on Pearl Harbor, when all other airports within 150 miles of the Pacific coast had to move their airplanes inland, Reid-Hillview was allowed to keep its tenants by removing propellers and other critical engine parts. The children's interest in aviation, fueled by news of the war and by popular aviation-related games, puzzles, and books, was boosted when local high school students were called upon to create aircraft models that would teach gunnery students to distinguish between enemy and friendly aircraft. By the end of 1942, hundreds of thousands of models had been completed. Unfortunately, the students' enthusiasm couldn't make up for a decided lack of consistency and accuracy. Their hand-carved wooden aircraft soon gave way to mass-produced injection-molded plastic.

Hundreds of these and other models, including a few of the hand-carved variety, are displayed at the Museum of Aircraft Recognition at Reid-Hillview Airport, next to the Flying Country Club. The tiny museum is hidden in the back room of CollectAir, a gallery and retail store that sells aviation memorabilia. A pre-publication copy of *The Spirit of St. Louis,* signed by the author ($1,275), sits in a glass case under an aluminum 1:50 scale model of a Scandinavian Airlines Douglas DC-4 ($1,100). But admission to the museum is free, and owner and curator Steve Remington is happy to guide visitors through his collection of aircraft recognition teaching materials.

"These are my favorite," he says, pointing to a wall display of about 75 German Wiking models built to 1:200 scale. Before World War II, Wiking sold model ships and airplanes made of metal. They were so precise that during the war the German government used Wiking owner Friedrich Peltzer's new injection-molded plastic models as training aids. When British bombs started raining on Berlin and the Russians were about to overrun his factory, Peltzer hid his molds in a well and escaped to the West. After the war, he retrieved the molds and established a new factory, where today Wiking produces HO and N gauge railroad accessories.

Museum of Aircraft Recognition, Reid-Hillview Airport, 2555 Robert Fowler Way, San Jose, CA 95148. Phone (408) 259-3360. Open weekdays and the first Saturday of each month, 10 a.m. to 5 p.m. Free admission.

The museum's display of Wiking models, a good test of your own recognition skills, includes aircraft from seven countries. Remington has also built an interactive display in which you can pretend you're the pilot of a Royal Air Force Spitfire tracking a target 200 yards away through the reticle of a Mark II reflector gunsight. Is it a German Messerschmitt or a British Beaufort? Do you fire or go on your way? You begin to appreciate the role recognition models played in handling the split second when proper identification meant life or death.

On the other side of the museum, Remington has recreated a military training room. Look out a window at a painting of the Santa Rosa Naval Air Station of 50 years ago. Models hang from the ceiling, posters line the walls, flashcards litter the tables, and notebooks lay open on the desk. It's easy to imagine that the cadets will return any second.

"There's so much stuff," Remington says. "I could never tell the whole story." Still, he's made a valiant effort. One of his displays traces the evolution of recognition models from the hand-carved wooden creations of the high school students through plaster of Paris (too fragile), rubber (too droopy), metal (too heavy), and papier-mâché (too rough) to injection-molded plastic. There's a "Target Kite Mark I" used in gunnery practice that was invented by Lieutenant Commander Paul Garber, who went on to found the National Air (and later Space) Museum's aircraft collection, as well as a display of 1:432 scale models that could be carried, like change, in a pocket. Another display is devoted to the millions of cardboard models assembled by GIs whiling away shipboard hours on their way overseas. Remington even has recognition models of airplanes that never existed, products of imperfect intelligence.

While the thrust of the museum is the second world war, there is an exhibit depicting the silhouettes used for training in World War I and another display dedicated to the Ground Observer Corps, a force of 350,000 volunteers who filled the gaps in the early-warning radar system during the 1950s.

"As a collector you find this stuff everywhere," Remington says, "though it's getting harder because World War II stuff is getting more recognizable as a valuable collectible. But sometimes you just fall into things."

Remington would love to find a pair of binoculars used in the civilian volunteer spotter program that was active on both coasts during World War II. Mrs. Hope Keller, whose observation post was up on Hecker Pass, some 20 miles south of Reid-Hillview in the Santa Cruz Mountains, donated her identification guide, arm band, and deactivation letters shortly before she died. A pair of the crude government-issue binoculars that she and half a million other volunteers used to scan the skies would complete Remington's display.

—Elaine de Man

PLANET EARTH
A COMMEMORATIVE EARTH DAY POSTER FROM THE APRIL 1990 SMITHSONIAN

The Poster measures 21¾" x 28¾"
Printed on Recycled Paper
Allow 4 to 6 weeks for delivery

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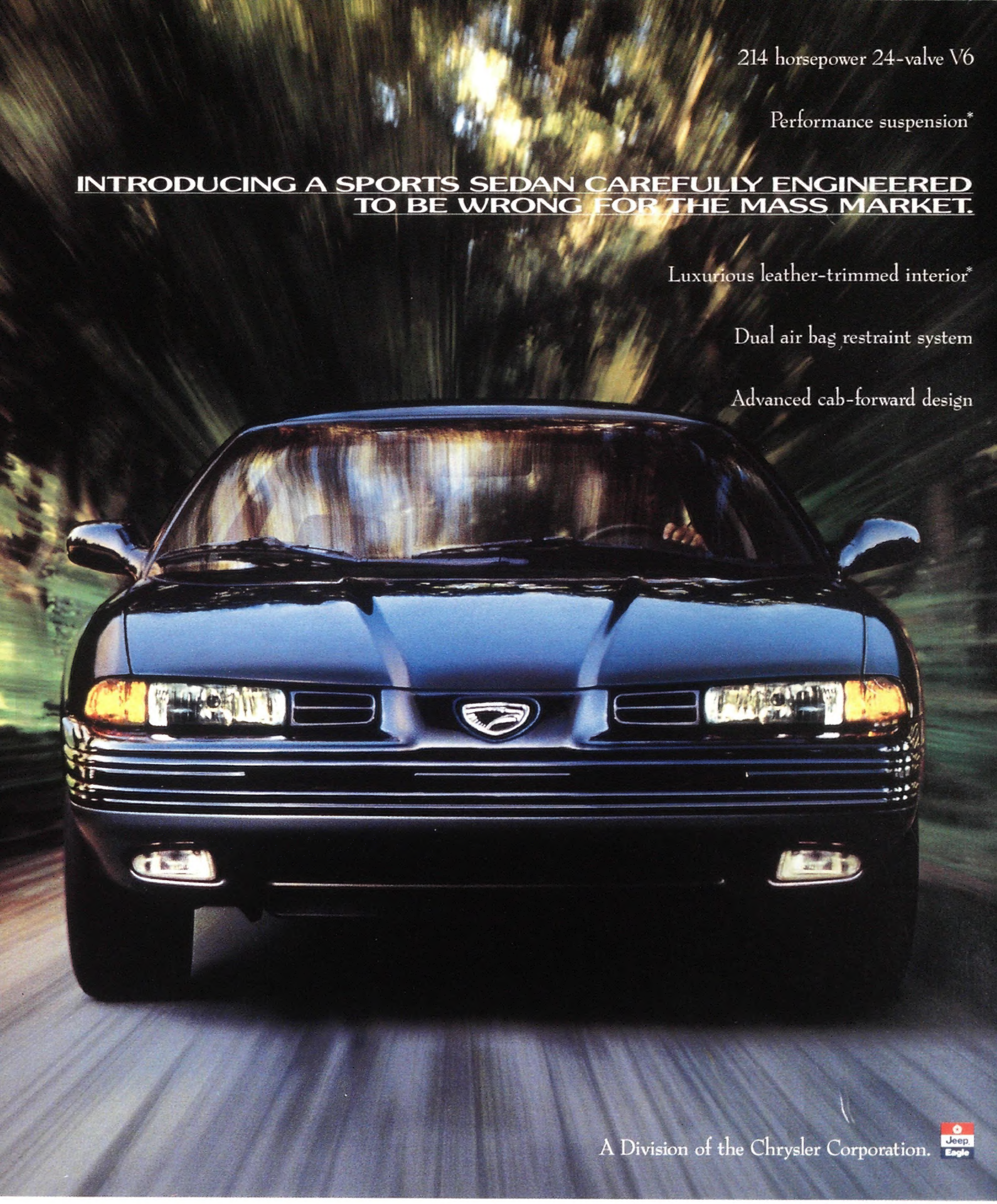

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